Lessons Learned from Advanced Information Technologies on Jobsite for Construction Education

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Abstract

This paper presents survey results used to identify the need for the advanced information technologies and construction activities that would benefit the most from the use of information technologies on construction sites. A survey was designed and conducted to gather a consensus of the construction industry in order to identify the perception of such technologies and their effects to professionals in the field. Twenty-one responses were received from participants in the Southern California area. The analysis results indicate that in a general consensus, the construction industry is not only dependent on the changing information technologies, but also that construction companies have discovered the efficiency developed through the implementation of such technology allows them to increase profitability and ultimately lower the potential for construction delays and undocumented issues that contractors wish to avoid at any cost. The findings will help academia develop the construction curriculum when integrating advanced information technologies.

Introduction

Advanced information technology, such as Building Information Modeling (BIM), has transformed the way the construction industry operates its business practices. Many construction companies have gradually adopted newly advanced information technologies based on the company's needs. The items such as the iPad, personal mini computers, and the vast array of software available used to enhance management and design aspects of a business are all

examples of advanced information technologies that have quickly become a common appearance on the construction site. Implementation of these new technological advancements has proven to increase productivity and efficiency, and also reduce cost and time on successful construction projects. The use of advanced information technologies on a construction site will definitely prove to be vital since everyday construction managers use the technologies to coordinate and communicate on the job site. In line with current construction practices, construction engineering management students need to understand current information technologies and their implementation on the actual job site in order to better prepare for future employment.

The availability of advanced information technology and its practical use on the construction site is again revolutionizing the industry through increasing productivity, efficiency, and visibility. These recent technologies will undoubtedly have a profound impact on how organizations operate on a daily basis. Advanced information technology aids in having correct documentation available at a moment's request. Being able to fill out forms, incident reports, and daily progress reports in the field increases efficiency and overall accuracy of such reports. These technologies also save time by reducing the amount of trips back and forth to the job trailer to acquire needed information,

allowing for more immediate decision making in the field. Ultimately, readily available information allows companies and project teams to reduce risk and exposure to failure as project teams will be confident that the decisions made are based on the latest most current information. Advanced technologies and their implementation on the job site aid in the coordination and communication efforts on construction projects. The use of Building Information Modeling (BIM) in the field, having readily accessible construction documents, and being able to create and review reports in the field, will establish a level of coordination and communication that to this date has been unseen in the construction industry. The implementation of such technology will encounter many roadblocks; such as cost, training, discomfort with such changes, and commitment to the use of the technology. Although these difficulties may affect the implementation of the new technologies, the benefits will be immediately evident and the savings to projects will attract attention from all corners. Coordination in construction through the availability of information is of upmost importance. Unfortunately, proper and constructive coordination is an issue that many construction projects face. The central problem of coordination arises from the fact that the relationship between the parties on a construction project has the character element of an "interdependent autonomy." This independent autonomy plays through the technical interdependence of the work and the organizational independence of those who control the work. For more than three centuries, the construction industry has been struggling to reconcile this technical interdependence and organizational independence (Higgin and Jessop 1965). According to Higgin and Jessop (1965), when "Looking at the building process, we can distinguish three main functions. Two are obvious: design and construction. The third is coordination." Coordination is one of the most sensitive functions of management (Chitkara 1998).

Communication problems are frequently occurring at the construction job site, where both paper documents and electronic equipment may be easily damaged. Recently, affordable tablet and wearable computers were introduced to overcome such problems. The use of tablets and tablet computers provides a more efficient method of communication between the fieldworkers, and onsite and off-site collaborators in building design and construction. Proper communication and improvements in early phases of projects would positively influence the quality of the projects, as perceived by all stakeholders involved in a construction project (Emmit and Gorse 2003). Improved communication will lead to better decision making through proper coordination, as well as proper implementation of the design intent.

One of the oldest issues in the literature regarding the adoption of technological innovations is whether diffusion is driven more by technology-push than by demand-pull mechanisms (Nam and Tatum 1992). Similar to the wave of the computer-aided design software and now the different building information modeling software, the new integrated construction management and information technology onsite will revolutionize the industry to a place where project information is always just a few seconds away. The compelling advanced information technologies in the construction industry with sufficient economic incentives will overcome barriers and benefit each individual player in the whole supply chain. Over the next decade, the combination between technology tools and business incentives will form the core of a strategic vision for advanced information technology in construction. Therefore, this paper examines the current technology being used on the majority of construction sites, the new evolving technology, as well as the benefits and roadblocks to adopt such technology.

Research Methodology and Data Collection

There is little empirical data regarding the current level of advanced information technology and the implementation of such technology on the construction site. Since there is no benchmark to be met for future improvements, a survey methodology has been implemented. The survey was generated in order to gauge professionals in the construction industry regarding their experiences with advanced information technology on the construction site. The questionnaire was formulated to derive conclusions from the professionals' past experiences, comfort and ability with current technology available, as well as any future advancements they would support. The questionnaire gave directions on how to properly answer the proposed questions and requested the participants to provide basic information regarding the industry currently worked in, years of experience in that particular industry, and the company currently employed with. The questionnaire consisted of twenty-one questions split amongst categories, and included a section for comments if the participant had any to include. The survey focused on three main areas of information technology and its implementation in the construction industry:

Part I: New technology and current use of present technologies in the field (6 questions) Part II: Improvements to current technology (12 questions) Part III: Future trends of technology (3 questions)

Part I of the survey was constructed to determine the level of use of current technology available in the field. This section was also geared to gauge the opinion of the participants on their openness to new, emerging technologies, and their perception of the importance of new technology to the construction industry. Part II was primarily comprised of questions that regarded how improvements in the current methodology of day-to-day tasks would affect practitioners. Questions were asked concerning how the job would change if the availability of information that one is accustomed to being in the construction onsite trailer would now be available in the field. This information would prove very valuable as perhaps some users and/or professionals in the industry may be reluctant to change their procedures for conducting business. The realization of the benefits of having such information available onsite would become very apparent in these responses. The questions proposed in Part II are directed towards all aspects of construction management and towards improving the communication level between various parties that make up a construction team. Part III, similar to Part I, was comprised of only a few questions to determine if new trends in the industry would prove helpful to users in the field. This section, again, was intended to evaluate whether or not professionals in the construction industry would welcomingly adopt new technologies in the field.

The questionnaire was distributed to construction professionals who are currently or have been employed by construction management firms or those involved with onsite construction in the Southern California area. A total 21 responses were received from the 50 surveys distributed. The survey respondents have in average 11 years of work experience in the industry. Of those responses, 62% were from the construction management industry and 38% from the architectural field. The large response from the construction management industry is due to the fact that more than half of the surveys were distributed at a construction job site. Architectural and engineering firms are typically more attuned with emerging technologies and deal daily with Computer Aided

Designs of buildings. The construction industry, largely, does not incorporate the use of such technology on a day-to- day basis. Rapid or significant changes to methodology are thereby unsupported. While new trends in the industry are moving towards adopting new management software which aid in the communication efforts onsite, its implementation and the orientation required to move forward may prove challenging for the individuals not accustomed to the use of technologies and advanced technologies.

Analysis and Findings

Every industry adopts new technologies as they become industry common place or when individuals within that industry find it beneficial to make changes necessary to adopt new strategies or technologies. Question three in Part I of the survey proposed the statement, "The use of new advanced technologies will be costly and over complicate things unnecessary." As shown in Table 1, of those surveyed, nearly 70% disagreed or strongly disagreed with the statement, and about 25% remained were neutral with the statement. These results signify that a very minute amount of people would disagree with the statement. This would signify that advanced technologies, in the viewpoint of industry professionals, would simplify the procedures used in managing the construction industry. In addition, this would also translate that the benefit of using such technology would outweigh the costs.

Table 1. Advanced technologies complication & cost.

Advanced technologies will be costly and over complicate the industry						
Strongly disagree	Disagree	Neutral	Agree	Strongly agree		
38%	29%	24%	5%	5%		

The availability of having project documents in the field is of great benefit to industry professionals who spend the majority of their time in the field. These documents allow for immediate decision making and reduce visits to the office trailer, which causes delays. In addition, when decisions are delayed in order to refer back to project documents that are located in the office trailer, there is a certain amount of human error that needs to be considered. The ability to resolve conflicts in the field when they arise is very valuable. Table 2 tabulates questions one through three of Part II of the survey. These questions focused on gauging the industry's benefit to having documents available in the field. Of those surveyed, over 85% agreed or strongly agreed that having project documents available in the field would be a benefit to their work. This indicates that of those surveyed, the majority find it beneficial in having documents available to them in the field. A construction foreman will normally have a half-set ofplans to refer to while out on the project site; these plans will undoubtedly see much mistreated and, over time, will need to be replaced. Having such plans available electronically will give ease when referring to the plans and will confirm that the most current set of documents are being used to make the most accurate and sound decisions.

Table 2.	Project	documents in	the field.
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Having project documents available in the field would be a benefit to my work						
Parameter	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	
Request for Information	0%	5%	10%	33%	52%	

Plans	0%	5%		5%	38%	52%
-	Specifications	0%	0%	10%	33%	57%

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Part II of the survey also presented questions regarding real-time data entry of reports. The ability to create and review reports in real-time adds to the efficiency of the construction project team. Real-time reporting would allow professionals to create reports and give project status updates as they develop. Also, efficiency and accuracy of reports is improved as the project team will not lose time when going back to the office trailer to document occurrences, which may lose accuracy in the forgetfulness of the human mind. Real-time entry of reports and requests will decrease the amount of error in such reports.

Questions eleven through sixteen were presented to gauge industry professionals' point-of-view on real-time data entry at the construction project site. Table 3 displays the results of those questions. Over 70% of those asked either strongly agreed or agreed with the statement that "Real-time data entry of reports is more efficient and more accurate." This statement was presented differently over six different statements in relationship to the topic. This demonstrates that people believe the real-time process or procedure would produce positive results and prove beneficial to the construction management team. There was no overwhelming differences between the results of those six questions asked, and it is noteworthy to mention that, on average, only 5-10% of those surveyed disagreed with that statement, and not a single person surveyed strongly disagreed with the statements.

Question	Real time data	entry of	reports are	more efficient	and accura	ate Pa	- rameter
	Strongly disagree	Disagree	Neutral	Agree	Strongly	agree	Daily
reports	0%	5%	14%	55%	21%		Safety
incidents	0%	10%	21%	48%	17%		
Inspection requests	0%	7%	17%	45%	26%		_

Another trend in construction projects is the availability of Internet access to the construction team onsite of a project. In today's world, with the wide use of smart phones and the Internet access they provide, it is difficult to imagine a construction project site that lacks the use of Internet. Though, for tablet devices, personal laptops, or computers, the availability of a wireless network onsite will be beneficial in that information can flow freely to all of those who require it. Questions one and two of Part III address the availability of wireless Internet and the access to email to those in the field of the construction project. Of those surveyed, an overwhelming 90% agreed or strongly agreed that having Internet and email access while on a project site would prove beneficial, as shown in Table 4.

Table 4.	Email	and	Internet	access
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Wireless internet and email access on the construction site would be beneficial to my work						
Strongly disagree	Disagree	Neutral	Agree	Strongly agree		
0%	2%	7%	33%	57%		

Discussion and Limitations

Throughout the process of distributing the survey to industry professionals, discussions arose

about the benefits and drawbacks that advanced technologies and their implementations can produce. Advanced information technologies provide solutions for, at times, tedious operations and procedures. These technologies simplify such tasks so that the procedural aspect of management is minimized. For example, when project architects receive or answer Request For Information (RFI), they review, answer and distribute the request to the project team. Rather than being bombarded with RFI unrelated to the scope of work, certain technologies allow teams to create alerts that when certain RFIs are answered, those alerts are sent out. This increases the efficiency of the team in that architects and construction management teams are not required to distribute RFIs to each individual. The project team is notified instantaneously upon that RFI being answered, allowing for increased efficiency, less delays, and immediate decision making.

The advanced information technologies that have arisen over the years have truly redefined the way certain tasks are completed. With the use of AutoCAD, BIM, and other building modeling software, the tedious time consuming tasks of drafting and sketching have been nearly absolved. One item to note is the precision and/or accuracy and experience of the person using such software. One person surveyed mentioned that drafters and those who used to hand sketch shop drawings and plans were meticulous in their precision. Those drafters had intimate knowledge of a building's design and interconnectivity. Based on this individual's experience, he stated that "These days people creating shop drawings and plans are skilled in running those difficult to use programs and lack intimate knowledge of that which they are designing." He added that, "When those drawings were hand drawn, they were only sketched once and were rarely changed; with drawings today, it's difficult to find a set that hasn't gone through a complete overhaul."

The adoption of these advanced information technologies has proven to beneficial and cost efficient, although there are a few industry factors that hinder the adoption of the construction industry's innovations that are critical to analyze (Toole 1998). Among the leading hindering factors is that cyclical sales could increase the squeeze felt from high fixed costs and low profit margins on total contract value, which, in turn, increase the risk of high capitalization costs. It is important to note that today's surge in information technologies should not compromise the skill and expertise of the staff that run a particular project. It is without any doubt that a project will experience changes in design; what is not acceptable is that those changes are caused by individuals who are unfit to produce such drawings. The technologies available to project professionals and project teams should in no way hinder the quality of the work. The technologies are present to allow for efficient delivery, accuracy and immediate access to available materials. Companies that use technology of this sort will find that the costs will quickly be outweighed by the benefits. Companies will discover that the efficiency developed through the implementation of the information technology will allow them to increase their profitability and, ultimately, lower the potential for construction delays and undocumented issues that contractors wish to avoid at any cost. The rapid movement from CAD to BIM by professional architects, engineers and construction management has shown that the design and construction industries are willing to make the necessary changes in order to keep up with the technological advances in information technology.

Concluding Remarks

This paper presented survey results that aimed to identify the perception of the advanced

technologies and their effects from the construction professionals' perspective in the construction industry. A project team will discover new emerging techniques and methods to accomplish tasks in a more cost and time efficient manner. These discoveries are what continue to drive all industries to be more competitive and become more valuable. Specific to the construction industry, the information technology now available in the field at the project teams' expense is potentially an industry changing technology. Integration of items like the iPad, personal mini computers, and the vast array of software available to enhance management and design aspects are quickly becoming a common appearance on the construction site. The analysis results showed that these technologies for both coordination and communication in the field help them increase productivity and quality of the work process, which ultimately increase profitability and lower the potential delay and undocumented issues.

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