Engaging Capability Training in Serious Game Technology for Delivering Industrialized Construction

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ABSTRACT

This study intends to introduce the use of digital media as a tool for learning in the Architecture, Engineering and Construction (AEC) industry. The main purpose of this paper is to determine how industrialized technology trainers in a developing country can improve their knowledge transfer to the construction workforce during their respective capability training sessions. This is a survey paper on selected literature regarding effective learning and capability improvement for skilled laborers specifically for assembling industrialized building components. It identified major problems in skill training for laborers at construction sites and highlighted gaps in current training curriculum involving adopted technological knowledge transfers. The authors are proposing how serious game approach could fill in the identified capacity training gaps especially for industrialized construction in Malaysia. The results support the role of serious games as a training tool by allowing trainees to be more engaged through meaningful learning activities.

BACKGROUND MOTIVATION

The Malaysian construction industry has endured lackluster financial performance over the past decade, making the construction industry as the smallest contributing sector to the total GDP in the economic sector of Malaysia. While the level of construction productivity in developing countries is lower than the developed countries, scholars are crying for a holistic approach in reviewing factors impacting the construction industry value chain (Zakeri, Olomolaiye, Holt, & Harris, 1996; Jayawardane & Gunawardena, 1998; CIDB, 2007). The nation's Construction Industry Development Board (CIDB, 2007) reported the need to address two vital strategies against the "Dirty, Dangerous, Difficult" image of the construction industry: 1) Developing and attracting human resource capabilities particularly among local workforce, and 2) Leveraging the level of knowledge, information and communication technology within the construction community.

The construction industry is facing challenges both in the global and local market due to its belated adoption and adaption of advanced construction-enabling technology. It is undeniable that the late reception is due to a host of economic and social factors in Malaysia. In recent years the Malaysian construction industry has been slowly migrating from traditional practice to Industrialized Building Systems (IBS). Such reengineering of human capital development, changing conventional mindset, and developing better cooperation and integrity are affected by this migration (Shaari & Ismail 2003).

Ball (1996) stated that considerable proportions of workforce in industrialized construction sector are general laborers who have limited training, education and capability. In Malaysia, IBS was chosen to promote social sustainability of low skilled laborers while aiming for the national economic sustainability. This paper is an attempt to document the underlying issues in capability improvement surrounding the local low skilled laborers. It covers emerging technology and knowledge transfer for overcoming the labor crisis in the construction industry. The aim is to identify the gaps and recommend the development of potential IT-supported mechanism to facilitate effective learning of adopted IBS technologies.

CONSTRUCTION LABOR CRISIS

This section covers selected literature review on human capability in construction industry. In recent decade, the population of the construction workforce is ageing with relative shortage of young people entering the construction workforce firm. SAMI (2008) is concerned about the ageing of professional workforce (Engineers, Designers, and Technicians) in the construction industry. The study it conducted found the professionals' problem was the lesser problem compared to that of laborers (sub-contractors) in the sector. The reason is, skilled laborers are getting physically less able to extend their working lives when they are approaching retirement age specifically if they continue working with conventional manual construction system.

The paper agrees that human behavior is extremely prone to errors during the construction activity. This is due to the complexity of construction processes which are affecting the cost and accident probability (Yang & Li, 2011). Prior study by Palaneeswaran, Ramanathan, & Tam, (2007) stated that design and construction errors in projects would result in reworking and creation of wastages that would affect performance and productivity of a building project. Hence, the paper foresees a need to integrate education, knowledge and learning throughout the construction process from design, production and building operations if the construction industry wants to attract young entrants into this sector.

Several recent studies have revealed potential factors that could have combined to influence the construction skills' shortfall. Dainty, Ison, & Briscoe, (2005) identified six factors that shaped the UK construction labor market skills crisis: 1) Changing in demographic and fluctuating nature of the market; 2) The introduction of new technology; 3) Quality of skills; 4) Growth in self-employment; 5) The recruitment challenge; and 6) Labor market regulation. Whilst these factors combined to influence the construction skilled laborers, the scholars also identified potential remedies for reducing the skill issue among the workforce. They are grouped under three thematic headings namely: 1) Skills requirements and impacts; 2) Recruitment and retention; and 3) Training and

qualifications. It is in these aspects that the authors are proposing their future study to focus on.

Coincidently, a study in China by Sha & Jiang (2003) on rural laborers' status highlighted four policy issues for implementation by its construction industry: 1) Structure of the labor market; 2) Calculation and award of labor costs (wages and benefits); 3) Provision of vocational training; and 4) Creation of organized labor and negotiation. These issues also provide glimpses into possible future remedies for reforming the construction industry. They aim to improve the overall quality and efficiency of the large rural workforce in this sector. Here again, the authors also foresee the need for improving the overall quality of rural workforce through educational and vocational training, development of working skills, organization of labor, awareness of democracy, etc. This paper supports these factors because the same issues would lead towards enhanced productivity, stabilized workforce, reduced work accidents, and improved quality of output with high profitability in the construction industry.

Based on those prior studies, the authors found a need to consider the vocational training and work productivity aspects among skilled laborers in order to enhance construction productivity. We now move on to how technology and knowledge transfers happen in order to improve the learning environment.

TECHNOLOGY AND KNOWLEDGE TRANSFERS

In this section, the paper presents selected literature findings about the techniques of capability transfer of advanced technologies with a view to improve learning mechanisms among general construction laborers in developing countries. The authors agree with Ioannou & Carr (1998) that capability building through knowledge accumulation and learning is fundamental to the innovation and knowledge transfer processes. Indeed, they agree with the scholars that the successful production and construction performance strongly depends on capability improvement through innovation and how quickly laborers could adopt the new technologies.

In general, a simple positive relationship of IT/ICT investment to the construction productivity can be observed (Zhai, 2010). In this respect, studies by Fruchter, (1999) and Ibrahim, Fruchter & Sharif (2007) have proven that IT/ICT can facilitate exchange, sharing and acquisition of technology and knowledge in the Architectural, Engineering and Construction (AEC) industry. According to van Egmond (2012) there are various learning mechanisms such as learning by doing, learning by interacting with upstream or downstream source of knowledge, learning by absorption of new developments in science and technology, and learning by querying what and how competitors are doing.

Indeed, there are various types of existing technologies for learning and transferring the knowledge to the learner. According to Tang, Hanneghan, & El Rhalibi (2009), there are some terms available to describe the use of computer-assisted games for learning. Among them include game-based learning, educational games, edutainment, training simulators, and most recently serious games. Serious game represents emerging aspects of learning in computer-assisted games. The prospect of looking deeper at utilizing the serious game technology as a learning platform is very exciting. Evidences from studies conducted by Dickinson, Woodard, Canas, Ahamed, & Lockston, (2011) and Lin, Son, & Rojas, (2011) have so far demonstrated successful applications and

implementation by construction practitioners to engage and leverage their knowledge to minimize errors, save valuable time, and reduce the risk of possible monetary losses. All these benefits are clearly aiming for higher productivity industry.

The authors' arguments are supported by Dawood (2009) in the Virtual Reality (VR) Roadmap "A vision for 2030 in the built environment", which reported the need for labor and workforce training in the construction sector. The report recommended significant R&D to address this urgent training need. In his study, Dawood projected that training of future industrial workforce would be competent by using technology. In fact, Dawood (2009) recommended specifically the VR technology to be utilized as a training tool for engineers and construction workforce.

In another study, the serious game is defined by Zyda (2005) as "a mental contest, played with a computer in accordance with specific rules, that uses entertainment to further government or corporate training, education, health, public policy, and strategic communication objectives" (p.25). Moreover, Tang et al. (2009) described serious game as an interactive software content that takes advantage of game technologies for non-entertainment purposes with a different reach in the context of education and training. In lieu of the above, the authors would like to recommend further studies on how high technology can be culturally adopted for capability training to suit the local laborers.

Whitton (2009) recommended several practical issues for consideration when using computer-assisted games to support learning. Among them are integrating a set of design principles for effective learning in games, aligning learning outcomes with gaming outcomes and assessing games-based learning. The authors are noting these aspects for developing a clear pedagogic justification; hence, would like to recommend such systemic approach when developing any new serious game development. It would serve to validate the context of future training tools, ones not simply adopted based on their perceived motivational effects on performance improvement. The authors also note that any curriculum development involving serious game tools is not an easy task.

The study on effective design of serious game applications by Lin et al. (2011) revealed that such training method could flourish as an AEC training approach. An earlier study by Ibrahim et al. (2007) has recommended using IT/ICT in expediting learning of building professionals working on global projects. A feature of this approach would serve to overcome the technology divides between professionals from both developed and developing nations since the authors foresee more projects would be located in the latter countries. Therefore, this paper would like to discuss how further studies could propose on designing an effective curriculum based on combining serious games approach and IT/ICT tools for learning, in line with the local work productivity approach.

DISCUSSION AND CONCLUSION

This paper had identified ageing laborers and lack of new adopted technology knowledge transfer as the top two problems in the construction industry. This section will now present why the serious games could be adapted for a successful knowledge and technology transfer for encouraging young entrants into the construction industry. They are divided into two: direct trainees' benefits and embedded trainers' opportunities.

Direct trainees' benefits. The authors believe a serious game approach for construction training curriculum could bridge the lack of direct incentives and benefits to trainees in the following manner.

i. A serious game training module could provide an exciting new perception towards a career in the construction industry. It is as opposed to the "Dirty, Dangerous, Difficult" the industry is known for. The game's entertainment environment—although could be embedded with heavy pedagogical content—has potential in adding the value of fun to non-entertainment domains in its training curriculum as mentioned above. Instead of "studiously learning" a technology and its knowledge aspect, a serious game format, instead, could motivate indirect learning via the competitive nature of the game itself. Through points and rewards collection during game playing, the trainees learn and remember the learning objectives along the way.

ii. A serious game could provide alternative access to real project experience. Where access to real projects is scarce and the number of trainees is large, a serious game environment is a safe environment to introduce trainees the early aspects about safety and site operation pertaining to a specific new technology. This early introduction can provide trainees the opportunity to apply and test their skills in a serious game environment, a chance they would never have in reality (Sherif & Mekkawi, 2006). Moreover, the attractive graphical interface can provide experience closer to real project when using VR tools and equipment as per recommended by Dawood (2009).

iii. A serious game could reduce exposure to risk and hazard during training. During the training module, trainees are allowed to explore the best practice or solve a problem based on their individual judgment. Rausch & Catanzaro (2012) recommend a serious game approach to allow acquisition of task familiarity without the risks of being on-site such as causing costly mistakes to the machines or industrialized components in the real job-site environment.

Embedded trainers opportunities. The authors posit that a serious game approach could provide major competency training opportunities for technologies developed from foreign counterparts. With synergized collaboration between technology providers and the trainers, several opportunities are recognized below.

i. A serious game could bring trainees into a close to reality operational context. The authors note the advanced visualization capability in current IT technologies. It could provide opportunities to trainers to prepare and equip the trainees about on-site operation. Playing a game application could inform the trainees on key issues when handling a new technology. Therefore, when they actually enter the next level of technology training on the real construction site, they could focus better on actual safety issues and equipment handling matters pertaining to the new introduced technology.

ii. A serious game could provide some kind of measuring system as per the competing gamers when playing entertainment games. Further study is recommended on measuring the self-competitiveness among entertainment

gamers to benchmark for capacity building (Sherif & Mekkawi, 2006). The authors are also recommending further studies on methods and techniques for developing self-dependency during the learning process, and methods for embedding evaluation mechanisms throughout the training module for easy trainer's evaluation. In time, the authors believe that the local trainees would learn and adopt the new technology

iii. A serious game could have the targeted learning outcomes embedded in the design of a serious game application. Trainers could apply selected predefined pedagogical learning outcomes in accordance to well-prepared training manual on requirements for real construction job-site tasks. As mentioned in the benefits for the trainees, the most exciting notion to the authors is the capability of indirect learning for the trainees who are mostly not interested in bland classroom-setting learning environment still dominant among developing nations. It is here that a training curriculum could adapt the application of new technologies according to the local laborers' preferred ways.

iv. A serious game training solution could help reduce liability cost by reducing the initial risky exposure to its trainees. Dickinson et al. (2011) had earlier recommended integrated advanced visualization technologies in providing appropriate interactions with computer-generated objects. The authors agree that the approach could help minimize physical training requirement and avoid costly and hazardous mistakes. Hence, technology trainers could select competent trainees for the next level training or repeat the off-site training until the trainees have reached certain competency level albeit in less expensive settings.

In conclusion, developing nations including Malaysia acknowledge the importance of IT/ICT tools for revolutionizing the method of construction among Architectural, Engineering, and Construction (AEC) practitioners. This paper recommends further studies in merging IT/ICT and serious games approach for expediting the learning of skilled laborers. Results of such studies would encourage the development of practical training curriculums with serious game technology, which the authors believe could promote sustainable social and economic changes in the local construction market.

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