ACT-UK SIMULATION CENTRE: OPPORTUNITIES AND CHALLENGES FOR RESEARCH

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Advanced Construction Technology Simulation Centre (ACT-UK) has recently been established at Coventry University, to provide an innovative facility for training future construction managers, enabled by semi-immersive virtual reality model of construction sites. In a typical training session, the trainees will face one snap-shot of construction site situation, called 'scenario' with the presence of various actors who will introduce site problems. By referring to information presented to them and interacting with the actors, the trainees will need to make decisions, and will receive feedback once the session ends. This innovative training presents important research challenges, especially due to many less well understood factors of the formation of skills afforded by this approach and the impact on performance in the workplace. The focus on 'soft' skills (rather than 'hard' technical skills) further heightens the complexity of understanding and 'measuring' the efficacy of this training. Within this context, the paper aims to propose a research framework, via a critical synthesis of key literature in related domains. The conceptual framework stands on three key sequential stages of pre-, on- and post-training, with one or more research themes in each stage. The framework integrates several research themes for harnessing the utility and realizing efficacy of this innovative learning approach. The research activities emanating from the framework will help to widen opportunities for the use of the ACT-UK in the future.

Keywords: communication, education, simulation, training, virtual reality.

INTRODUCTION

Virtual Reality (VR) technology has been heralded as a powerful visualization tool for various applications in construction and engineering sectors. In the education sector, the utilization of VR has promised many benefits, notably the ability to simulate physical space and environments in which the learners are able to feel the presence and immerse themselves as if they are in the 'real' environment, but without the excessive resource requirements and potential hazards of a real-time situation. This can potentially enrich the learning experience of the users, as well as provide alternative learning approaches not permitted by traditional learning delivery in typical classrooms or lecture theatres. Specifically, VR could facilitate innovative pedagogic approaches such as problem-based learning or activity-led learning, which are currently being encouraged and implemented in Coventry University.

Coventry University Enterprises Ltd has secured multi-million pounds funding from the Regional Development Agency, Advantage West Midlands, to set up a purpose built training facility – Advanced Construction Technologies Simulation Centre

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(ACT-UK) at the Coventry University Technology Park (Stothers 2007). The facility has been open for business in September 2009. Being the second in the world and the only one in the UK, this facility offers a unique training for future construction managers, enabled by semi-immersive VR of construction sites. Training based on VR technology is not new; several examples of training enabled by this technology do exist, such as training of high-risk occupations with a high level of investment in infrastructure such as pilots and astronauts. However, the ACT-UK will provide a simulated environment as if the trainees have to deal with the pressure and complexity of running a real construction project. The ACT-UK will enable trainees to undergo virtual on-site training in a controlled environment without the safety or cost implications of learning on the job. The VR technology is probably of secondary importance, but the learning environment created by various actors in real project scenarios is novel, and represents significant research opportunities and challenges.

The aim of research presented in this paper is to propose a research framework afforded by the establishment of ACT-UK as an innovative approach of training construction managers, through a critical synthesis of key literature in related domains. First, an outline of training in ACT-UK is presented, and followed by a discussion of the significant of 'soft' skills in project management and how these skills could be afforded by training in ACT-UK. Then, four intrinsic dimensions underpinning the formation of 'soft' skills are elaborated. Finally, potential research themes illustrated in a conceptual model which explains their relationships are presented. Key issues and potential research questions are also explained. This model is intended to provide a framework of 'thinking' research for harnessing the utility and realizing the efficacy of this innovative learning approach. The research framework is proposed to empower and enrich learning activities in the ACT-UK, and ultimately helps to widen opportunities for the use of the simulation centre in the future.

TRAINING IN THE ACT-UK SIMULATION CENTRE

ACT-UK was developed based on Building Management Simulation Centre (BMSC) in the Netherlands (de Vries *et al.* 2004). Three main components of ACT-UK are site huts, a 3-D virtual construction site projected on a large parabolic screen, and a control room. Here, the trainees undergo training sessions based on scenarios which are designed to reflect the complexity of running a construction project. The scenario is a snap-shot of construction site situations, and developed via information capture in a real case project (Austin 2010a). The 3-D images of construction site corresponding to the scenarios were captured at every stage of project development, and then projected onto the parabolic screen. This exposes the trainees to a virtually real project environment which enhances the feeling of being on the construction site. However, the actual training sessions occur within the site huts (i.e. site office) where the trainees are presented with site problems associated with the current stage of development. The site huts provide relevant equipment (e.g. PC, telephone) and various project information (e.g. master programme, contract documents, resources, lists of suppliers and subcontractors). An important part of the scenarios is the presence of professional actors who play the roles of related personnel such as site workers, delivery staff, and colleagues (Stothers 2007). The actors enliven the scenarios by having face-to-face contact and introducing site problems to test trainees' decision making and communication skills. The presence of the actors enriches site problems with behavioural stimulants to pressures and stresses associated with running a real construction site. By referring to information presented to them and interacting with the actors, the trainees will need to make decisions. Additionally, the

trainees may receive several phone calls from the control room which remotely notifies verbal information, instructions, and emerging site problems such as delay of material delivery by suppliers, variations by the client, or conflicts between parties. The training session is supervised by experienced site managers and other construction professionals, who sit in the control room. The control room is fully devised with multimedia equipment including dedicated computers with bespoke software, LCD monitors able to view each site hut and parabolic screen, and telephone lines. The actors also receive instructions from the supervisors in the control room.

A typical training session lasts about 1.5 to 2 hours, followed by a verbal feedback from the supervisors in a dedicated one-to-one session for about half an hour. In addition to active involvement in the training sessions, feedback session and reflection are intended as effective means to sustain trainee motivation (Garris *et al.* 2002). The emphasis is always placed on the positive-side of trainee's behaviour as observed during the training session. The supervisors refrain from saying anything 'negative', but instead may suggest areas which need to be improved. As each scenario was lifted from a real construction project, the problems presented to the trainees are real problems with solutions recorded during project information capture (Austin 2010a). Hence, a comparison between the decisions made by the trainees and those by the 'real' construction manager could be undertaken. This helps to evaluate trainee's decisions and assess the consequences of the decisions. This training is fundamentally different from that of AROUSAL Simulation System, which focuses on strategic decision making and general management of construction firms (Lansley 2003). The ACT-UK training accelerates the maturity of site managers with operational decision making skills in construction projects, which seems to be an interesting proposition for the advocates of 'quick-fix' to skills shortage. However, the implications of disrupting the learning curve of the formation of management skills would indeed deserve further research. The following section elaborates the skills afforded by the simulation centre and their significance.

THE IMPORTANCE OF 'SOFT' MANAGEMENT SKILLS

Good project management skills are essential for successful projects and identifying these skills have been a major pre-occupation in project management field. Several Bodies of Knowledge in project management (e.g. PMBOK, APMBOK) elaborate the required skills and knowledge to enhance the likelihood of achieving successful projects. However, they can not guarantee success as there are areas which can not be easily codified, make explicit and transferred from one project to another. Furthermore, PMBOK has been criticized as placing more emphasis on the technical 'hard' skills rather than on 'soft' people relationship skills (Pant and Baroudi 2008). Dainty *et al.* (2003) recommended moving beyond traditional measures of outturn performance, in terms time, cost and quality, for evaluating the performance of construction project managers. Instead, they proposed a range of measures revolved around management inputs (i.e. success factors) to overall project success, which include both 'hard' and 'soft' measures in order to provide a holistic impression on the competency of potential project managers. Later, they found that softer measures to be the most predictive of superior to average performance (Dainty *et al.* 2004). Despite the arguments outlining their importance, it is difficult to identify and get a consensus of 'soft' skills requirements, l*et al.*one measuring them objectively and systematically (Muzio *et al.* 2007). Also, 'soft' skills are much more difficult to teach and learn than 'hard' technical skills (Pant and Baroudi 2008). However, with increasing complexity

of running modern projects, there seems to be an increasing need to equip project managers with the 'soft' skills and competencies (Müller and Turner 2010).

Training in ACT-UK is geared towards developing 'soft' skills of construction managers. A development team from BMSC and ACT-UK has proposed a list of competencies and skills, which were considered critical for developing good project managers (Stothers 2007, Austin and Soetanto 2010). These 'soft' skills categories include 'leadership', 'understanding of client needs and contract requirements', 'planning and organization', 'monitoring and controlling performance', 'problem solving and risk management', 'team and people management', and 'communication', which underlie the development of training scenarios. Each scenario has particular focus on one or several categories within the list, but not all categories, and therefore a number of scenarios were created to ensure a comprehensive coverage of the categories. So far, there are over 120 training scenarios, based on two real construction projects; a multi-storey office building and a housing development (Austin 2010a). Training could take between one half day to five days, depending on the requirements, but of course, longer duration will allow more comprehensive and complex training. Costs seem to be one of the most important considerations in determining training duration (Austin and Soetanto 2010). Additionally, the ACT-UK has identified four main intrinsic dimensions which underpin the trainee behaviours; imagination, knowledge, passion, and power. Understanding of how these dimensions are mobilized during training session deserves further investigation, but is beyond the scope of this paper. Here, their definitions are discussed in the following section.

IMAGINATION, KNOWLEDGE, PASSION, AND POWER

'Soft' management skills, described by Muzio *et al.* (2007) as 'micro-social' skills, may have been developed from early up-bringing (de Freitas *et al.* 2006) to life experience in the workplace. These skills are formed and re-formed through a continuous active interchange between individual conscious and unconscious processing of personal learning experience. Early conceptualization of experiential learning is described as Kolb learning cycle (Kolb 1984), although the model tends to support more 'conscious' learning, in which learning is regarded as a 'deliberate' act. It is argued that the antecedence of 'soft' skills is the resultant of thought process involving innate knowledge, imagination, heuristic and intuition. The challenge is to create the enabling conditions for these to flourish in the workplace (Hodgkinson *et al.* 2009). A discussion of the antecedence of 'soft' skills is as follows.

Imagination is required for establishing future consequences of decision, considering risks, anticipating the other party behaviour which would allow an individual to form his/her behaviour and expectation within the decision making process. Imagination is also an engine of creativity, in which an individual deploys available explicit and tacit knowledge the decision making process. One key question is whether effective decision is served by objective rationality or subjective irrational judgements (see Soetanto and Dainty 2009 for discussion). At individual level, the perception of the future consequences and risk of making decisions is a product of heuristics, intuitions, affective, value, and other socio-political and cultural factors (Soetanto and Dainty 2009). Some consider heuristics and intuition as a common term, but here they are differentiated as intuitions can include heuristics. Heuristics can be a source of biases for the intuitions. The form of intuition is subdivided into 'expertise' and 'feeling' (Miller and Ireland 2005). Intuition-as-expertise is an accumulation of conscious and unconscious learning over time, and often overlapped with the heuristics, whereas

intuition-as-feeling is more dominant in the exploration of future uncertainty. In this case, the reasons behind decisions based on 'feeling' often can not be totally articulated, but the decisions are just felt right (Miller and Ireland 2005). Leybourne and Sadler-Smith (2006) pinpointed that intuition based on expertise may drive improvized behaviour which is a product of non-conscious and irrational judgement. Improvization is an important aspect of decision making with limited (or lack of) information and time. Whilst several studies exist in the deployment of intuition and heuristic in corporate decision making, there is a lack of information of the formation and role of these skills for those at middle management level and in particular, how to harness them for their effective utilization in dynamic real-time scenarios.

Power underpins inter-relationship between parties (and individuals) on a construction project. Fellows *et al.* (2009) defines power as the ability to pursue own desires in preference to those of others, including overcoming any resistance from e.g. environment. They further argued that two forms of power in construction are 'wealth' as in the ability to commission work, and 'knowledge' as in the realization of projects by designers and constructors. Harmonious relationship could be viewed as a transaction which relies on one party submissive to the power of another due to reward offered by the party possessing the power. This transaction occurs at different levels, notably at project level between the client and the contractor, the contractor and the subcontractor, and also within the relationship between individuals on site. On day to day transactions between individuals on site, the perception of owning excessive power from those holding supervisory roles may be realized through a decisive behaviour (which may be a good thing for the project), but at the same time, may jeopardize the relationships due to (perceived) aggressive behaviour. This may have repercussion to overall project performance and contractual relationship in which one party (or individual) may withdraw from the project, refrain for performing to their best, or at worst may sabotage the project. The pressure of meeting performance targets germinates conflicts between individuals, and hence there is a clear need of appropriate skills to suppress aggressive behaviour, and hone assertiveness in the decision making. The ability to regulate the emotion to avoid aggressive behaviour and promote assertiveness is the key skills of successful construction managers.

In learning, a person is said to have a passion for something when they have a strong positive affinity for it (Wikipedia 2010). Individual's passion in construction projects has a positive influence on performance (Dainty *et al.* 2005). The learning approach in the ACT-UK is to promote active engagement and implant a passion of dynamic work in construction, knowing that the work produces useful artefacts for the future.

A FRAMEWORK FOR RESEARCH

Central to the research framework is to establish a greater understanding of the formation of 'soft' skills enabled by this new learning approach and to address how the skills acquired impacts on individual, project and organization performance in short and longer-terms. In order to elaborate upon this, key themes and related issues are mapped against three stages; before, during and after training, as presented in a conceptual model Figure 1. The model illustrates an iterative, sequential relationship in a loop, where one stage informs the next, with one stage comprises one or more themes. However, it is not the intention to segregate each theme independently of each other; a research can cut across several themes and stages. Also, it is not meant to formulate a comprehensive list of research themes; it is very much a living framework

for developing research afforded by the establishment of ACT-UK. Research themes in each stage and their research questions are explained in the following paragraphs.

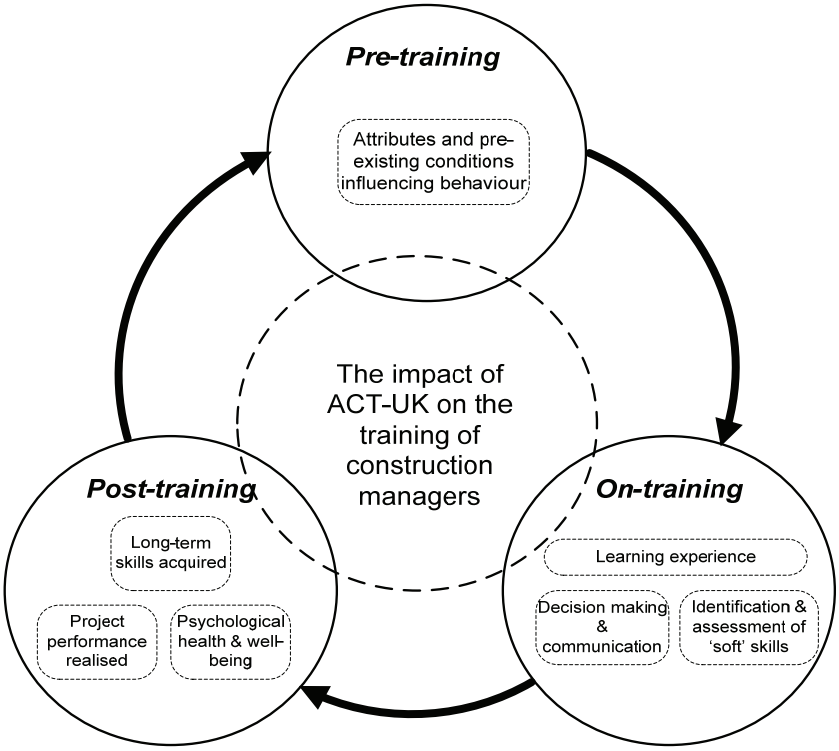

Figure 1: Conceptual model of research framework

Pre-training stage

Research at this stage concerns attributes and pre-existing conditions influencing the behaviour of construction managers. It focuses on intrinsic characteristics of individual and projects, which facilitate the learning of 'soft' management skills. A number of studies have been undertaken to address a key question of what makes a successful project manager (e.g. Dulaimi and Langford 1999; Dainty *et al.* 2004). However, the key issue that this research will address is to identify the factors which facilitate and are amendable by the learning approach in ACT-UK, to determine how the factors could be modified, and to assess the impacts of these modifications. Considerations may include personal attributes such as background education, personal orientation, motivation and rewards, and project and team attributes, such as team relationship, position power, task structure, and involvement (Dulaimi and Langford 1999). For example, previous study by Dulaimi and Langford (1999) suggests that 'soft' skills are obtained by workplace experience and new graduates tend to emphasis on the technical aspects of project management. The key question is whether the technical education background hampers the training of 'soft' management skills, and how the technical orientation could be re-aligned with the requirements of 'soft' skills training. Essentially, the research lays a foundation for research in the next stages.

On-training stage

This stage encompasses three research themes, including decision making and communication, identification and assessment of 'soft' skills, and learning experience, which conceptually can subsume the first two themes. Research in 'decision making and communication' theme concerns the decision making process and the interplay of various antecedences of making a decision (such as heuristics, intuition, rationality of

judgement, imagination). The key issue is how these being expressed in the real construction scenarios, in terms of negotiated transaction of relationships between personnel involving emotion, response to pressure, and perceived ownership of power. This training will permit an experimental design research, and potentially produce evidence to its efficacy.

Research on identification and assessment of 'soft' skills will provide a focus for training by addressing several key questions; what criteria are the most appropriate for a particular scenario or a set of scenarios? Are there definitive and all-encompassing criteria? How and who should set the criteria? How the assessment could be administered? Who is the best person to assess the trainee performance against the criteria? How can the criteria be used to drive the learning process? Can the criteria (and other assessment mechanisms) serve as an incentive of learning? The underlying approach is founded on social-constructivist view in which skills and knowledge is shaped and evolves through increasing participation of trainees with direct support from the supervisors (Cole 1990).

ACT-UK places the trainees at the central stage of learning experience. Research on 'learning experience' theme revolves around the impacts of this new approach of learning in terms of the formation of 'soft' skills resulting from disrupted learning curve; the feedback mechanisms; the relationship between the trainees, the actors and supervisors; trainee experience of the process. The skill formation prompts the need to re-connect the learning process and clear learning outcome, and the ability to retain skills acquired for future. Failure to connect learning process and outcomes has been blamed for the low take up of simulation learning (de Freitas 2006). The research also seeks appropriate feedback mechanism; existing approach utilizes one-to-one feedback session. The question is whether it is the best feedback mechanism. Are there alternatives for different types of skills categories? Simulations and scenarios have supported professional and vocational training needs, but are rarely employed to support conceptual and higher level cognition for more abstract learning (e.g. in the areas of strategic decision making) (de Freitas 2006). Can group feedback (e.g. focus group) be used to enhance abstract learning and the sphere of thinking through socialization of knowledge? How can this feedback be enhanced by the use of cognitive tools (e.g. discussion forum, cognitive mapping) (de Freitas 2006) for group and self-reflection?

In terms of relationship, how has the role of each party changed in the process? The approach has shifted the role of supervisor of learning from teacher to facilitator and/or coach. This new role is interesting, but at the same time, quite challenging. Macdonald and Savin-Baden (2004) argues that shifting role in problem-based learning may prove more difficult for the tutor than for the student. The research will also examine the conditions that facilitate the trainees taking active role in learning, the extent to which the trainees feel empowered by this new learning approach, and identify issues surrounding learning in the simulations from the trainee perspective.

Post-training stage

Research at post-training stage focuses on realizing the efficacy of the training through a greater understanding of the deployment of skills acquired, process that allows the skills to flourish in the workplace, and strategies to sustained their positive impacts on project performance. The research themes at this stage are related to the retention of skilled acquired by the trainees in the long term, the impacts the training might have on the project performance, and the health and well-being resulting from

the deployment of 'soft' skills acquired. The underlying aim is to dismantle the barriers to the take up of simulation learning due to the lack of empirical evidence of its effectiveness (de Freitas 2006).

A study by Clarke (2010) on the impact of training to enhance EI abilities of project managers indicated that the effect of 'soft' skills training would develop over longer time period. The development of 'soft' skill may continue to take place through on-the-job learning mechanisms (Clarke 2010). It might seem reasonable to argue that the 'soft' skills acquired would need to be confirmed by real life events in the workplace. This phenomenon might well be explained by a 'confirmation for habituation' process in which the trainees matches (and mis-matches) between the experience of learning in the simulation and actual experience on construction site. Thus, the trainees seek confirmation(s) of their actions and/or decisions to enhance their confidence of their efficacy. The processes, mechanisms and enabling strategies of this longer term learning are the focus 'retention of skills acquired' theme.

Research on the impact on project performance aims to establish appropriate project performance criteria and the linkage between the 'soft' skills acquired by the trainees and the realized project performance. A number of scholars have argued that 'soft' skills of project managers are major contributors to project performance (e.g. Dainty *et al.* 2004), but there is little evidence on the processes and mechanisms which delineate the connection between 'soft' skills and project performance. The real challenge is to identify project performance criteria within which the impact of training could be demonstrated. Austin (2010b) attempts to measure the impact of ACT-UK training on project effectiveness, but a rigorous methodology is yet to be found. Yahaya (2007) investigated the effectiveness of immersive VR technology on the development of decision making skills during crisis events (i.e. factory breakdown, in manufacturing sector) of undergraduate business degree students. The findings highlighted the important role of facilitator and the authenticity of VR as a simulation tool. However, lack of integration between various learning events has undermined the role of simulation in the formation of decision making skills. It is suggested that various factors mediating the relationship between training 'soft' skills and project performance, which has made establishing such relationship less straight forward. The impact of this new training approach may be tangible and less tangible, and likely to be realized in the longer term. The positive impact of employee well-being and psychological health in construction has been suggested by the Respect for People movement (M4I 2000), and subsequent researches to capitalize on this (e.g. Soetanto *et al.* 2007). Good 'soft' skills will facilitate the creation of stress- and conflict-free environment, leading to a more collaborative approach in the construction project environment. The impact of training 'soft' skills on psychological well-being is a venue of further research.

CONCLUSIONS

The establishment of ACT-UK Simulation Centre has presented opportunities and challenges for research on training future construction managers. The main contribution of ACT-UK training is on providing a learning mechanism which enables trainees to gain experiential 'soft' management skills which are usually acquired through working life over longer time. Following the training, the trainees are able to make a mental leap toward a maturity as site managers. Additionally, the training has promoted deep learning via an innovative approach of learning-by-doing and learning-from-consequences, which is often considered as more advantageous and perhaps

more intuitive than traditional lecture. This approach arguably heightens the participation and motivation of learners. However, previous study found that the absence of empirical evidence of the effectiveness of simulation learning has prevented the wider take-up of this innovative learning approach. Further, a recent investigation revealed that the costs associated with ACT-UK training have been prohibitive (Austin and Soetanto 2010). The goal of the exploratory study presented in this paper is to develop a conceptual framework which underpins future research initiatives to demonstrate the efficacy of ACT-UK training. The framework also positions the research within existing knowledge in this subject domain, and consequently demonstrates its potential contribution. Nevertheless, the aim of the paper is not to provide an authoritative research of the efficacy of ACT-UK, but to serve as a starting point and direction for further research and development. The framework is conceptualized through an iterative, sequential stages of training in the ACT-UK with one or more research themes in each stage. It is hoped that the research initiatives as instigated by this framework will help to alleviate some of the barriers to the take up of this innovative learning approach.

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