2018-04-21

Learning Through Successful Digital Opportunities for Effective Competition Preparations:Reflections of students and coaches

Lloyd Scott
Dublin Institute of Technology, lloyd.scott@dit.ie

Mark Shelbourn
University of Salford, M.Shelbourn@salford.ac.uk

Learning Through Successful Digital Opportunities for Effective Competition Preparations - Reflections of students and coaches

Lloyd Scott, PhD
School of Surveying and Construction Management
Dublin Institute of Technology
Dublin, Ireland

Mark Shelbourn , PhD.
School of the Built Environment
University of Salford
Manchester, UK

Education of the built environment is moving towards more collaborative practices. The intent behind the collaborative approach of teaching is to encourage students to explore the unknowns and unravel the problems themselves, with the professor acting as the facilitator. This paper presents a collaborative pedagogical approach that was adopted to teach students from two geographically distant universities. The occasion used was preparation of student teams for Associated Schools of Construction (ASC) student competitions. The participants began by engaging online in a virtual environment and later moved to face-to-face collaboration solving an interdisciplinary design build problem as part of the student competition. The authors adopted an action research method to enhance the capabilities of the students in understanding and generating constructive behavioral changes. The intention was to empower the students to explore new horizons by 'clarifying and negotiating' ideas and concerns. The authors evaluated the usefulness of this pedagogical approach based on direct and indirect measures. The pedagogical approach presented is a part of an ongoing initiative between three universities that have shown positive results based on the teams' performance in the competition as well as affirmative feedback from the student participants.

Key Words: Collaborative pedagogy, international collaboration, action research, case study

Introduction

Built Environment graduates in the future will need to be highly technical, adaptable, good communicators and lifelong learners (Hunt 2011). This goal provides the modern academic with many challenges. We hear commentators proffer that the current model of pedagogy, which is at the heart of the modern higher education experience, is becoming obsolete. In the industrial model of student mass production, the teacher is the broadcaster. However, we hear calls for a more constructivist learner-centered approaches. An active learning approach has the potential to create the opportunity to develop those skills, competences and understanding that graduates now require. This paper offers reflections on a collaborative learning project between the Dublin Institute of Technology, University of West of England and Oklahoma University architecture/ construction management students.

The holistic, interdisciplinary approach to the design, construction, production and operation of buildings is likely to require changes in the way the process is arranged, resourced and managed in the future (Atkin, 2009). There will be a different kind of professional in the twenty or thirty years whose education and/or training will be required to permit them to make the many connections in thinking and actions required to solve complex problems. Future construction professionals must challenge the conventional ways of the past in ways that use their creative and innovative capacities. Active learning experiences like the Design Build competition offer so many opportunities to develop this.

From a learning front, with technology, it is now possible to embrace new collaboration models that change the paradigm in more fundamental ways. But this pedagogical change is not about technology per se. This is not about distance learning. This is not about students being able to access lectures by some of the world's leading professors from free online sites like Academic Earth. Rather, this represents a change in the relationship between students and teachers in the learning process. The assessment of the learning involved in such an approach is easily measured; from the academics' perspective who observe students grow in confidence,

understanding and knowledge as they experience a positive constructivist learning engagement.

In becoming that 'guide on the side educator' has made the team better educators and has provided the motivation and appetite for future innovation. The continued support for the Dublin Institute of Technology, University of West of England and Oklahoma University initiative is vital to the creation of the future leaders in construction. Research has shown that collaboration among lecturers/teachers has positive outcomes for learning in areas such as engagement, attendance and achievement (Ahmed, 2013, Scott and Fortune 2013). Building on that idea, this paper presents the findings from this study and suggests, the factors, a learning by doing approach and curriculum innovation, were both strongly related with the factors of collaboration through mentoring and feedback.

Collaborative Education in the Built Environment

In North America McGraw-Hill have published a number of reports where they asked North American Architecture Engineering & Construction (AEC) firms their requirements for skills for collaborative BIM. In 2009 (McGraw Hill, 2009), they reported that "*…more internal staff with BIM skills, more external firms with BIM skills, more incoming entry-level staff with BIM skills and more readily available training in BIM were required to realize the potential value of BIM*." By 2012 (McGraw Hill, 2012) the updated report showed small decreases in the percentages allocated to the collaborative BIM skills required (possibly reflecting uptake by the industry), but collaborative BIM training was still placed among the top three targets for investment by industry.

These reports show similarities with Henderson and Jordan (2009) who suggested that some of the additional skill-sets (to their traditional single-discipline learning) industry requires included: "*…knowledge of data management, information technology, energy and material conservation, integrated building design, systems thinking, life cycle analysis, the design processes, business and marketing skills, and project finance*" (p. 35).

It is the role of educators to instil in all graduates the concepts of collaborative design and the full potential of collaborative team integration, before they learn about the "*old ways*" of working once they graduate (Shelbourn et al. 2017). The concept of creating job-ready graduates brings to the fore the "*training vs. educating*" debate. Gerber *et al.,* (2013) demonstrated that there has been resistance in the past among educators in providing training in collaborative computer technologies in universities, as many educators are unfamiliar with such technologies. This often means educators currently expect students to learn it by themselves, as they do many other software applications (Williams et al., 2009). Given these precedents, one can assume the same approach to learning collaborative BIM meaning students will tend to focus on the technological aspects, rather than develop an understanding of how BIM principles and processes could enable them to work more effectively with others in a collaborative team environment.

On the training v's education debate, many educators still view BIM as just another piece of Computer-Aided-Drafting (CAD) software that students should learn in their own time. Many argue that it is not the university's role to produce 'CAD technicians' and that there is little educational value in using CAD, or that CAD threatens creativity (Becerik-Gerber *et al.*, 2011). These concerns can be justified as the adoption of computers and 2D CAD has coincided with a decrease in documentation quality and productivity (Engineers Australia, 2005).

However, collaborative BIM is not merely a new CAD tool or computer application: it is a new paradigm and its benefits extend much further than 3D drafting (Chegu Badrinath *et al*. 2016). Students cannot be expected to "*teach themselves BIM*" any more than they could be expected to "*teach themselves structural engineering*" (Engineers Australia, 2005; Gledson *et al.* 2016). From a learning point of view, there is little difference between learning manual drafting techniques and learning 2D or 3D CAD. However, with collaborative BIM, every part of the design and construction process and can be compared, with building performance also modelled at this stage and monitored in the operation phase. Both 2 and 3D CAD merely provide a way of documenting information about the building, whereas collaborative BIM actually represents the building virtually with critical information contained within it to help optimise the operation of the facility throughout its lifecycle (Hu *et al.* 2017).

In addition to the resistance to using new technologies in teaching, faculties where this learning is taking place is also a barrier to learning (Shelbourn *et al*. 2016). Since engineering and architecture emerged as separate professions from the historical job title of Master Builder, students of the different disciplines have tended to be educated in isolation from each other. According to Pressman (2007, p., 3):

"*Many academic programs still produce students who expect they will spend their careers working as heroic, solitary designers. But integrated practice is sure to stimulate a rethinking of that notion. Pedagogy must focus*

on teaching not only how to design and detail, but also how to engage with and lead others, and how to collaborate with the professionals they are likely to work with later."

Starzyk and McDonald (2010) reported a focus of architectural education on developing individual skills, such as the ability to draw. More recently, they state, "…*the importance of personal skill is yielding to the primacy of collective knowledge*". Scott (2016) found little or no integration or collaboration between the disciplines in the majority of universities in the USA, Europe and Australia. Moreover, the first time that students are exposed to working with team members from other disciplines is in the workplace, post-graduation. Shelbourn *et al*. (2017) discussed this further, and said "…*it is important for graduates to have an understanding of the roles played by other professionals and the impact their decisions have on projects overall*." However, the lack of multi-disciplinary collaborative learning means students are not provided with such an understanding in much of the current curricula across these countries (Scott, 2013).

Another issue to consider is the complexity of modern building projects and technologies used in their design and construction. Such complexity means that nobody can be a master of all. Students learning in their silos lack a deep understanding of the information that each requires at different stages of a project (Shelbourn *et al*. 2017). What is required is for students to work collaboratively and to learn the requirements of the other disciplines before they graduate, often in multi-disciplinary modules, projects and even student competitions such as those offered as part of the Associated Schools of Construction in the USA.

The problem is not only restricted to students of separate disciplines learning in their own silos: different departments are often in separate departments, schools or faculties and can be located on separate campuses (Shelbourn *et al.* 2016). Sharing learning across the different silos is a challenge that needs addressing if graduates are to leave their studies with the key skills of understanding the importance of collaboration (Shelbourn *et al*., 2016). The need for change instigated by the BIM revolution (Cabinet Office, 2011) provides a great opportunity to rethink how teaching and learning is designed with educators becoming more efficient in delivering it (Shelbourn *et al*. 2017).

It is not all doom and gloom however. Hardy, quoted in Deutsch (2011, p. 202) stated, "…*when I look at the logic of construction means and methods that collaborative BIM inherently teaches, I see the potential to educate*…". Nawari (2010) noted that "…*students need to know how each discipline is related to the other and how one discipline impacts the other*". The role of collaborative BIM can offer a better opportunity to engage students more effectively and to help with their understanding of how buildings are constructed.

Mark *et al.* (2001) proposed "…*the ideal computer curriculum*…" for architectural education where computing technologies were added to existing curriculum without removing or adding subjects. Mark *et al*. (2001) offered two alternatives: one that merged technology into the traditional curriculum, the other a more radical approach that displaced some existing subjects. The approach was limited to teaching BIM modelling for visualization or analysis within the architectural discipline alone. Scott (2016, p.552) highlighted the case for setting education in the pragmatic paradigm, pointing out that "…*the freedom to work within the pragmatic paradigm offers diversity that can draw together some of the thoughts that challenge and build the arguments about the role and position of theory in construction education*" – certainly a useful consideration when looking at collaborative BIM education.

The challenge for academics wanting to educate undergraduates so that they can work effectively in collaborative teams, putting together virtual (and eventually real-life) buildings, is *when* and *how* to introduce elements of disciplinary knowledge, BIM technologies and development of team working skills. Collaborative BIM education should be effected in stages (Shelbourn *et al.* 2016), increasing in complexity as the students' knowledge of the building design and construction process grows (Gordon *et al*., 2009).

Solving a Distinct Problem in Multidisciplinary Education

The action research that is presented in this paper involved cycles of interactions between the authors and participants focusing on two separate objectives:

1. To enhance participants' learning to build capabilities and abilities to understand and generate constructive behavioral change through reflective action on assessment practice
2. To evaluate the usefulness of collaborative learning to enhance such actions by the participants as improving their learning.

Action research was deemed as the ideal methodology particularly as a holistic, in-depth investigation was the

goal (Feagin, Orum & Sjoberg 1991). While action research is distinguished by its purpose that is to affect change in the participants, the objective of the ASC student competition (specifically the 'International Design Build' competition) is to enhance the participants' capabilities. The study presented in this paper did not attempt to perform sampling research. Within the premise of the approach adopted in this paper, there is a choice to be made in relation to the number of cases to include and as the initiative will be ongoing it will very much be considered as presenting a number of case studies over time, the occurrence in consideration being the first.

Action Research

The growing use of action research within built environment education research and development initiatives explicitly recognize that collaborative approaches to student learning are not characterized so much by problems for which an answer must be found, but rather by issues which need to be resolved and will inevitably require one or more of the parties to change their views. The underlying assumption of these approaches is that effective social change depends on the commitment and understanding of those involved in the change process. Also, it is suggested that collaboration can provide people with the interactions and support necessary to make fundamental changes in their practice which endure beyond the research process. Action research comprises a family of research methodologies, which aim to pursue action and research outcomes at the same time. It therefore has some components which resemble consultancy or change agency, and some which resemble field research. The focus is action to improve a situation and the research is the conscious effort, as part of the process, to formulate public knowledge that adds to theories of action that promote or inhibit learning in behavioral systems. One of the key characteristics of this approach is collaboration, which enables mutual understanding and consensus, democratic decision making, and common action (Oja & Smulyan 1989).

In this sense the action researcher is a practitioner, an interventionist seeking to help improve client systems. "This help takes the form of creating conditions in the behavioral world of the client system that are conducive to inquiry and learning. Lasting improvement requires that the participatory action researcher help clients to change themselves so that their interactions will create these conditions for inquiry and learning" (Argyris et al. 1985 p.137). Hence to the aims of contributing to the practical improvement of situations and to the goals of developing knowledge we can add a third aim of action research, to develop the self-help competencies of people facing problems. Within this broad definition there are four basic themes: (1) collaboration through participation, (2) acquisition of knowledge, (3) social change, and (4) empowerment of participants. The process that the researcher uses to guide those involved can be seen as a spiral of action research cycles consisting of phases of planning, acting, observing and reflecting (Masters 1995). As Oja and Smulyan (1989) point out, the underlying assumption of this approach, which can be traced back to Lewin's (1948) writing that effective social change depends on the commitment and understanding of those involved in the change process. In other words, if people work together on a common problem 'clarifying and negotiating ideas and concerns,' they will be more likely to change their minds if research indicates such change is necessary. Also, it is suggested that collaboration can provide people with the time and support necessary to make fundamental changes in their practice which extends beyond the research process (Oja & Smulyan 1989). Thus the role of the action researcher is identical to that proposed for contemporary facilitators in helping communities identify and adopt more sustainable natural resource management practices (Pyecha 1988).

Feedback from Participants

The authors have collected initial data from the 27 participants of the recently completed ASC student competition (specifically the 'International Design Build' competition) to determine the usefulness of the collaborative pedagogical approach. These students were selected from their home institution where The authors asked several questions to the participants in the form of an online survey. The summary of the responses ~~are~~is presented below. The participants were asked to rate the different aspects towards the preparation of the competition in a ~~three-point~~three-point scale (very helpful, neutral, and least helpful). Almost all of the participants (94%) mentioned the support from the coaches was most helpful followed by support from the industry guest speakers (Figure 1). A major portion of the learning for the 'International' team ~~members~~member's entails getting accustomed to the construction and contractual processes of the US construction industry along with their jargons. The authors along with other coaches invited speakers from the industry to bridge this gap. The participants' low agreement on the helpfulness of the other faculty members may be due to preoccupation of the faculty members with other commitments. The virtual team meetings played an important role in the team building process spanning the educational and cultural diversity, and laying the foundation for collaboration. This team cohesiveness and collaboration among the members generated the sense of 'commonness' and the urge to work together for 'clarifying and negotiating' ideas. It has been the experience of the authors that during the week before the actual competition when the team ~~members first~~members first met face-to-face, a lot of unlearning and relearning took

place. By this time the social change could be seen taking grip on the participants in the form of changing their mind/ understanding or giving away preconceived notions if their joint research demands so. One of the participants commented:

"*The virtual team meetings are important but there is a significant lack of the subtle communication that makes meetings important. You can handle generic information and technicalities over skype but it is much easier for misunderstandings or potential issues regarding "closed" matters to go unnoticed."*

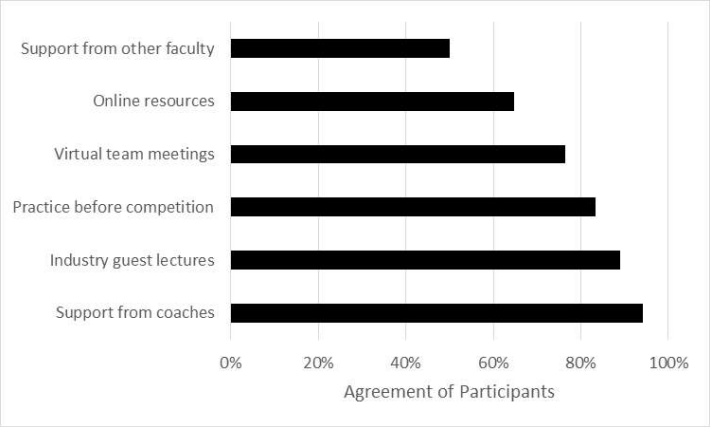

Figure 1: Participants agreement with usefulness of different aspects of preparation

Analysis

The feedback from the participants has identified that the learning context is a significant aspect to learning. Teamwork emerged as a real bonus and to understand the perspective of the other stakeholders was a very meaningful outcome; the architect learning from the construction manager and vis a versa.

The personal learning experiences speak for themselves and just a few of the personal reflections are shared here:

*The entire international design/ build experience I learned that **teamwork comes in all forms**. Our team did not meet face to face until 2 days before the competition but we broke the ice very quickly and bonded. For me, the entire experience proved that drive and determination will overcome any task, as one or as a group*

This project was an inspirational experience, full of fascinating people
***who exchanged ideas and learned ideas and learned from one another in a rich collaborative process**.*

*The entire competition and preparations were hard work but **Educationally rewarding plus a once in a life time experience**. From making friends half way round the world and here at home, getting to travel**, getting a glimpse of how the American's do construction**, and the really enjoyable time we all had working together as a team.*

The authors in conjunction with other coaches agree that the ASC competitions demand tremendous amount of effort and superior level of maturity from the participants. Preparing for these type of competitions ~~are~~is always challenging and involves some level of unpredictability. Subsequent to the completion of the competition, when the participants were asked about their level of preparedness going into the competition, a vast majority (76%) answered in affirmative. The factors identified by the participants that facilitated in the preparation process included (but not limited to) the practice sessions with the team, the feedback of the coaches, the online and physical meetings, and so on. Comment by one of the participants highlighted the social change and empowerment of the participants, which was the objective of this ongoing action research.

"*…. each member had specific strengths and experience in their part of the project. These were identified early in the process so preparation could be maximized."*

One of the objectives of the action research was to evaluate the usefulness of the collaborative pedagogical approach. The authors based their conclusions on two measures: the performance of the student teams in the ASC competitions and the individual perceptions of the participants. While the strong performance of the teams provide testimony in favor of the collaborative approach, the indirect measure based on the participants' perceptions were also equally positive. A few comments shown below will demonstrate the positive change in the participants'

attitude, knowledge, and competencies.

"*The team work was definitively the best aspect. As part of the international team, we met new people of different nationalities and this was extremely interesting."*

"*...competitive and very challenging competition that strengthens students for a similar real life situation in the student future career.*"

Lessons Learnt

In terms of offering colleagues in the CM discipline some words of wisdom from the authors reflections, the first comment would be there is no manual for finding our way through this type of initiative. Despite the previous experience in this collaborative approach to enhancing the student experience all coaches are very much of the view that this is the students learning experience and so imposing a pre-prepared structure on the team was not going to work. With the practical aspects and personal interactions that this kind of team experience requires a loose structure for the teams to consider and reflect upon is proposed. As might be expected, the process will be quite alien to any group at the start, so it is important to provide as many resources as possible to the team members.

Some of the fundamental points to consider would be:

Allow the members of the group to share their knowledge and gain confidence - allow and schedule time for this as this will require more time than you might expect

Encourage them to schedule meetings outside of the designated times

Do not rely on the online interaction to be the definitive way to communicate

Encourage the team members to challenge assumptions

Ensure that team members, especially those who will have to travel to the competition acquire as much background knowledge as possible

Embrace the student-led collaborative efforts that lead to team success and look for ways to foster it

Make any expectations clear to the them members

Be comfortable with the fact that this is the students experience and so they may encounter some obstacles.

This kind of truly collaborative approach demands a major time commitment. One cannot assume that the team members know what it is they are going to say and roll with it as easily. Be prepared to have situations that will take more time than you might have scheduled for. The time spent will allowed team members to deepen their understanding of the requirements to be successful, improve interactions with each other, develop a capacity to embrace differences, and work toward a more collaborative approach to solving the project. This interesting account of two teachers who truly collaborated as they jointly taught shows how much teachers can learn when they work together. This endeavor will be time-consuming, but remember it has the potential to provide a commensurate amount of personal growth and development for all concerned.

While English is the common language, there will be some culturally subtle differences. For example, construction terminology can be quite different across the globe and experience has shown the authors that it is only when the students meet face to face that they really get to understand those differences. This holds true for the measurement systems too, non U.S. students tend to need to up skill themselves on the imperial system as they are usually conversant with the metric system only. This often provides for a huge learning curve on the part of the visiting architect and the estimation students in particular.

Discussion and Future Direction

The authors reflected on a number of advantages such a collaborative learning format - social benefits, learning benefits, and development of skills, knowledge and competences for the students' future careers. The early stage virtual meeting was embedded to reduce the social anxiety of students by providing an instant group of peers with whom they would not feel exposed. Instead they would feel a sense of community through engaging in the common task of grappling with and understanding the competition structure and the material associated with it. Secondly, it was hoped that the method would help to promote deeper understanding, especially for the international students as their knowledge and experience in the US construction processes was very limited. The upskilling and deep learning around US practice of estimating and health & safety regulations challenged the international students but what did emerge was the experience of sharing of best practice from both processes. While the international students certainly had a steeper learning curve the overall emerging theme was one of a deeply constructive learning experience and one that they participants have indicated would be lasting.

The future directions to consider by both the authors and the construction education community is how such really meaningful learning experiences get embedded in the educational experiences of the learners we come in.

Some positive starting points include:

- Continued collaborative engagement
- Share what has been developed to date
- Develop a rotational model that allows students to participate abroad
- ***Encourage other Universities to participate***
- Create shared mission of active learning approach
- Create significant learning opportunities for Built Environment students

Students were exposed to different styles of thinking, and different ways of tackling the problems. Having already thought about the problems, the arguments and comments of the coaches were more meaningful to the students. Thirdly, the authors thought that interacting in small groups would give students practice in communication and interpersonal skills useful in their later careers. Construction professionals often operate in formal or informal small groups, asking questions and advising peers, sometimes accepting and at other times rejecting ideas. Construction professionals also form their own opinions by synthesizing the contributions of others with their own previous experience and knowledge. The authors thought that the competition format would provide valuable practice in these skills.

It is the intention of the authors to build on this research where the research/ analysis of the different cycles will impact on future work. So, while an action research approach has been taken this project will be ongoing trying to build on previous experiences with a view to learning and improving. What is offered is a phase of the research cycle and the reflection and learning will continue as we go forward with each cycle. Changing the model of pedagogy and the model of knowledge production is crucial at program level for the survival of the university and the programs they offer.

References

Ahmed, A. K. (2013). Teacher centered versus learner centered teaching style. *The Journal of Global Business Management. 9* (1) 22-34

Becerik-Gerber, B., Gerber, D. J., Ku, K. (2011), 'The pace of technological innovation in architecture, engineering, and construction education: integrating recent trends into the curricula', *Journal of Information Technology in Construction,* **16** (2011): 411-432

Cabinet Office (2011) Government Construction Strategy. Available from: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/61152/Government-Construction-Strategy_0.pdf accessed on 24th September 2017

Chegu Badrinath, A., Chang, Y.T., & Hsieh, S.H. (2016) *A review of tertiary BIM education for advanced engineering communication with visualisation*. Visualisation in Engineering (2016) 4:9 DOI 10.1186/s40327-016-0038-6

Deutsch, R. (2011), *BIM and Integrated Design: Strategies for Architectural Practice*, John Wiley & Sons, Inc., New Jersey

Engineers Australia (2005), *Getting it Right First Time: A Plan to Reverse declining standards in project design documentation within the building and construction industry*, Engineers Australia, Brisbane. Available *at:* http://codebim.com/wp-content/uploads/2013/06/Getting-It-Right-The-First-Time.pdf accessed 27th September 2017

Feagin, J., Orum, A., & Sjoberg, G. (Eds.). (1991). A case for case study. Chapel Hill, NC: University of North Carolina Press

Gerber, D., Khashe, S., and Smith, I. (2013) 'Surveying the Evolution of Computing in Architecture, Engineering, and Construction Education.' *J. Comput. Civ. Eng*., ASCE, Oct. 7, 2013

Gledson, B., Hilton, D. & Rogage, K. (2016) *Benchmarking BIM Levels of Training and Education amongst Construction Management Practitioners.* In: Proceedings of the 32nd Annual ARCOM Conference, 5th – 7th September 2016, Manchester, UK.

Gordon, C., Azambuja, M., & Werner, A. M. (2009), 'BIM across the construction curriculum', in *Proc. of the 2009 ASC Region III Conference*, Downers Grove, Illinois, October 21-24

Henderson, L. & Jordan, N.L. (2009), 'A Modest Proposal for a Transdisciplinary Curriculum for the Design, Construction, Management and Maintenance of Architecture', *Journal of Building Information Modeling*, Fall 2009

Hu, Z.Z., Tian, P.L., Li, S.W. & Zhang, J.P (2017) *BIM-based integrated delivery technologies for intelligent MEP management in the operation and maintenance phase*. Advances in Engineering Software (2017), http://dx.doi.org/10.1016/j.advengsoft.2017.08.007

Mark, E., Martens, B. and Oxman, R. (2001), The Ideal Computer Curriculum, Architectural Information Management: *eCAADe Helsinki*, pp. 168-175

Masters, J. (1995) "The history of action research." Action research.

McGraw Hill (2009), *SmartMarket Report: The Business Value of BIM: Getting Building Information Modeling to the Bottom Line*, McGraw Hill Construction, Bedford, MA

McGraw Hill (2012), *SmartMarket Report: The Business Value of BIM in North America: Multi-Year Trend Analysis and User Ratings (2007-2012),* McGraw Hill Construction, Bedford, MA

Nawari, N.O. (2010), 'Intelligent Design in AEC Education', *ITcon* Vol 15, p 306-317, June 2010

Oja,S., and Smulyan, L. (1989) Collaborative action research: a developmental approach, Falmer Press.

Pressman, A. (2007), 'Integrated Practice in Perspective: A New Model for the Architectural Profession', *Architectural Record*, May 2007, http://archrecord.construction.com/practice/projDelivery/0705proj-3.asp

Pyecha, J. (1988). A case study of the application of non-categorical special education in two states. Chapel Hill, NC: Research Triangle Institute.

Scott, L., Fortune, C. (2013) "Towards the Improvement of the Student Experience of Assessment and Feedback in Construction Management Education." *European Journal of Engineering Education* 38 (6): 661–670.

Scott, L. (2015) 'The Changing Landscape of Construction Higher Education', *International Journal of Construction Education and Research*, 11:2, 78-78, DOI: 10.1080/15578771.2015.1022454

Scott, L.M. (2016) 'Theory and research in construction education: the case for pragmatism', *Construction Management and Economics,* http://dx.doi.org/10.1080/01446193.2016.1151539

Shelbourn, M., Macdonald, J. & Mills, J.E. (2016) *Developing an international framework for BIM education in the HE sector*. In: Proceedings of the 10th Academic Interoperability Coalition (AIC) BIM Symposium, 4th – 5th April 2016, Orlando, Florida, USA

Shelbourn, M., Macdonald, J., McCuen, T. & Lee, S. (2017) *Students' perceptions of BIM education in the higher education sector: a UK and US perspective*. Industry & Higher Education, 31(5), pp.293-304. DOI: 10.1177/0950422217725962

Starzyk, G.F. and McDonald, M. (2010), 'The Collaborative Dance: Only Three Steps' in *Proc of the BIM-Related Academic Workshop*, December 7-9 2010, Washington DC, eds. Salazar, G. and Issa, R.

Williams, A., Sher, W., Simmons, C., Dosen, A. & Pitt, B. (2009) *Construction Education in Australia: a review of learning and teaching challenges and opportunities*. Australian Learning and Teaching Council