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CASE STUDY: LESSONS LEARNED FROM BUILDING INFORMATION MODELLING (BIM) EXTRACURRICULAR ACTIVITY ORGANISED FOR ARCHITECTURE, ENGINEERING AND CONSTRUCTION STUDENTS WITHIN A UK UNIVERSITY

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ABSTRACT

Building Information Modelling (BIM) is a digital method of managing the physical and functional characteristics of a building throughout its life cycle. It promotes a collaborative working within the construction industry, an alternative to the current silo working mentality. To equip students with the right skills for future employment, a major university in the UK developed a BIM collaborative working extracurricular activity with the key interest in promoting multi-disciplinary teamwork. Personal experience suggests that this is an area where students find challenging and there are very few formal learning opportunities to practice this.

This case study presents both staff and students' view of this BIM extracurricular activity. Lesson learned from this research activity will be used for future iterations in how BIM is implemented within this particular university. This study can also be used as a preliminary to carry out further multiple case studies in the future. The data collation methods included the use of questionnaires, targeted at students who participated at the extracurricular activity; and an online focus group consisting of a number of staff members. The key findings suggest that both students and staff found the multi-disciplinary teamwork experience to be beneficial. However, as there are no opportunities to put this in practice in their final year, the benefits may diminish over time. Whilst students agreed that this extracurricular activity should be re-run, the long term focus is to implement it within the formal curriculum to ensure all students will benefit from it.

Keywords: education, Building Information Modelling (BIM), multi-disciplinary, extracurricular, case study

INTRODUCTION

Building Information Modelling (BIM) is a process of generating, storing, managing, exchanging and sharing building information in an interoperable way (Vanlande et al, 2008). With a complete implementation of BIM, various building information is shared across a multi-disciplinary team in a fully integrated and collaborative way, with information regarding timeline, workflow and cost attached to it. BIM encourages multi-disciplinary team collaboration. This is a positive shift from the current silo working mentality within the construction industry. Its implementation is seen as a way to improve productivity, efficiency and cost savings throughout the life cycle of a building/project.

The UK Government has a mandate to implement Level 2 BIM on all UK centrally procured public sector projects by 2016. Table 1 provides the definition of BIM maturity level in greater detail.

BIM Maturity Level	
Level 0	Data exchange process is in the form of unmanaged CAD and the use of only 2D design application
Level 1	Data exchange process is in the form of managed 2D and 3D CAD with collaborative tool embedded to provide a common data environment a standardized approach to data structure and format. Finance and cost management are not integrated and managed separately.
Level 2	Data exchange process is in the form of a managed common data environment (CDE). It may utilise construction sequencing (with time line and workflow attached to it) and/or cost information.
Level 3	A fully integrated and collaborative process enabled by online network/ web services. It is to be compliant with the Industry Foundation Class (IFC). This level utilises cost, time and other information to support the project delivery life-cycle.

Table 1: BIM Maturity Level (reproduced from PAS 1192-2:2013)

Despite there being no requirements to implement BIM within the higher education sector, students need to become familiar with its operation to ensure they are fully equipped for future employment in the construction industry sector (Underwood et al, 2013). A major UK university recognized the importance of this through the development of a multi-disciplinary BIM extracurricular activity. Emphasis was placed on fostering students' collaborative teamwork skills where students from various disciplines were grouped into a team of five or six. A weekly three hours extracurricular session was ran throughout the second semester of the 2013/2014 academic year. The extracurricular activity consisted of group tutorial and guest lectures sessions covering BIM case studies, protocols and its associated standards. Students were given a choice of two projects: 1) designing a Pavilion or 2) converting a roof space of the particular university's building into something usable and exciting. Two colleagues acted as the clients for the Pavilion and the roof conversion projects. An online video tutorial in the use of various technical BIM softwares (such as REVIT and AUTOCAD) was made available for students so that they could learn how to use the softwares at a time/pace that suited them. The extracurricular activity commenced with an inaugural lecture on Wednesday 3rd December 2014, which was open to all students in the AEC (Architecture, Environment and Construction). It was aimed specifically at the level 5/second year AEC students.

25 students attended the inaugural lecture and signed up to participate in the extracurricular activity. Assessment consisted of a group assignment (consisting of a group poster, presentation and report) and an individual written assignment (an individual reflective report of the extracurricular). Students had to show that they understood BIM and able to demonstrate a clear and concise interpretation of BIM to

their clients. They were also asked to provide advice to clients on the tools and techniques required to support collaborative working among the team for an effective project delivery.

Building Information Modelling (BIM) in Higher Education

Most studies of BIM have focused on the technical software. Little has been published on the use of BIM as a tool for learning and teaching (Eadie et al 2014). A key feature of BIM is in facilitating multi-disciplinary teamwork. Hence, it is vital that its implementation is integrated in a multidisciplinary environment for it to work effectively (Barison and Santos, 2009). Students in higher education need to gain experience of using BIM in a multi-disciplinary environment if they are to work effectively in the construction industry. Recent evidence indicates that a number of universities in the different countries have started introducing BIM in some ways to get students up to speed with the changing technology and to stimulate multi-disciplinary collaborative work.

Collaborative Working in Higher Education

The importance of encouraging students to work collaboratively has been recognized in the higher education sector for some time (Walsh and Kahn, 2010). It is widely recognised that students retain their knowledge better when they work co-operatively with their classmates in an active way. Teamwork skills also enhance students' employability prospects (Heywood, 2000; Karpova et al., 2009; Colbeck et al., 2000), better problem solving abilities, higher intrinsic motivation, and greater ability to transfer knowledge from one situation to another (Johnson and Johnson, 1989). Whilst in-class group work is widely used, less attention has been paid to multi-disciplinary and/or inter-disciplinary collaborative working environment and so far it tends to be in a form of an experiential learning environment. University of Ulster, for example, carried out a collaborative working to encourage students on the Architectural Technology, Quantity Surveying and Commercial management programmes to work collaboratively on a project (Comiskey and McKane, 2014). Cited in Long et al. (2013), research also suggests that students value these opportunities, as they are able to apply the theory based learning to real-life practice, more than traditional lecture or other classroom activities (Barber, 2007). In this BIM collaborative extracurricular activity, students encountered all the usual problems associated with working co-operatively in a team but they must also contend with the difficulties of understanding the jargon used by other specialists within the construction industry and seeing how their varied expertise can benefit the project.

RESEARCH CONTEXT

The aim of this research is to address this gap in the literature. The research ascertained the view of undergraduate students in the Built Environment and Architecture Faculty of a large UK University who had experience of working in an extra-curricular multi-disciplinary project using BIM. Staff members were asked for their views on the BIM project. The key research questions were as follows:

1. What is students and staff's perspective about BIM? Do they understand that BIM is more than just a 3D modelling tool and that it is about collaborative working in the construction industry among different professionals?
2. A year on, what is their opinion of the way the extracurricular activity was delivered? Could it be improved?
3. How useful has the extra-curricular activity been in facilitating collaboration in third year projects?
4. Did students develop any other skills that subsequently proven useful?

Lesson learned from the research would be used to shape decisions about the use of BIM in the curriculum.

RESEARCH METHODOLOGY

As there is little empirical data regarding the current level of BIM integration within the higher education curriculum setup in the UK, a decision was taken to conduct an in-depth case study of the extracurricular activity carried out in a major UK university. Case study method was used in this research as it allowed tailoring of the design and data collection procedures to fit the research questions. A mixed mode questionnaire, targeted at students who participate in the extracurricular; and an anonymous online focus group, targeted at member of staff with BIM knowledge, were used as the primary data collection method in this research project. This allowed for a large amount of data to be collected quickly in a standardized format with minimum inconvenience to participants (Denscombe, 2003).

Ethical Issues

Before the questionnaire and online focus group commenced, respondents' consent to participate in the research was obtained. Informed consent was essential to ensure that participants understood their rights in respect to the research. In order to protect the anonymity and welfare of participants and the integrity of the research, an ethical consent procedure was closely followed and an extended ethical form was completed for approval. Information sheet, advising them about the project, their right to anonymity and their right to withdraw, were distributed to participants.

Questionnaire design

Questionnaire was identified as the most suitable data collection method for capturing students' view in this research. This is done to gain both statistical data and qualitative insights. The questionnaire was designed in a mixture of open and closed ended questions. Closed ended questions were used to gather data quickly and efficiently

from participants. It allowed for it to be compared easily among participants, whereas the open-ended questions aimed to complement the close-ended questions as it allowed participants to post further extensive comments of their experience. Questionnaires were distributed to both completers and non-completers group. Participants were asked the following questions: 1) to define BIM and outline its purpose; and 2) to rank four key features of BIM, to determine whether they see BIM primarily as a technical tool or a tool for facilitating collaboration. Participants were also queried about their thoughts of the activity and for improvements in the future. It covered the following:

- Any aspect of BIM they can still remember (a year after they completed the extra-curricula activity)
- Any aspects of the extra-curricula activity helped them most in their third year of studies,
- What they feel was least useful about the extra-curricula activity experience,
- Would students recommend the extra-curricula to be re-run?
- Any improvement suggestions and,
- Whether the extra-curricula activity should be implemented as part of the curriculum.

Online focus group

Five key members of staff who are knowledgeable in BIM were invited to participate in an anonymous online focus group. As they would have a key role in influencing future decisions in BIM implementation, their views were sought for this research. Three agreed to participate. The online focus group method was chosen for its convenience and flexibility. To ensure anonymity and encourage an honest open discussion, a private online focus group was set up for this purpose. Participants were asked to use an anonymous nickname. The online focus group consists of three open-ended questions, as follows:

1. What do you feel is the pro and cons of BIM collaborative working to you and your students?
2. What do you think are the key things that are affecting the application of BIM and collaborative working in higher education (both positive and negative)
3. What is your view if BIM is to be adopted into the curriculum?

RESULTS AND DISCUSSION

There were 25 second year AEC students who signed up and expressed their interest for taking part in this extracurricular activity. However, there was a high drop-out rate and only six students completed the extracurricular activity, in the end. Of these, five who completed the extracurricular activity responded back to the questionnaire (two Construction Management students and three Architectural Technology students). The same questionnaires were distributed to the non-completers to gather their view and reasons for non-completion.

Students who participated in the extracurricular activity are now on their final year of study. The data collated from the completers highlights that they are all aware that BIM is more than just a 3D software and that it is about a collaborative multi-

disciplinary teamwork. The responses gathered also suggest that students view the People aspects of BIM as its essential feature, followed by Information, Process and Technology. Two participants, however, stated that all four aspects are equally important in BIM. Data collected suggests that all respondents would prefer BIM to be incorporated into the formal curriculum with multi-disciplinary project work. All respondents indicated that direct involvement in the multi-disciplinary collaborative teamwork was useful. It provided them with an insight on how various disciplines work together as a team and how BIM process works in a multi-disciplinary environment. They do not experience this in their formal curriculum. Responses also show that **three** out of **five** respondents have obtained additional skills in both the multi-disciplinary teamwork aspect and technical knowledge in using specialist BIM software. All participants stated that the extracurricular activity developed their understanding of BIM and this has continued to evolve throughout and after the extracurricular activity. One of the respondents specifically mentioned that their understanding of multi-disciplinary collaborative teamwork using BIM process has evolved further after the activity. It allowed students a better understanding of the different ways different disciplines operate. The extracurricular activity provided them with more confidence in using BIM specialist softwares and working collaboratively in a multi-disciplinary team. Nevertheless, the findings also show that the output from various BIM softwares are not standardised. This results in inconsistencies when the multi-disciplinary team shares building information from one format to another. The response gathered also suggests that main advantage of the extra-curricular activity is to expose students to a multi-disciplinary environment. Unfortunately, there are no opportunities to work in a multi-disciplinary environment in the final year at the moment, so the benefits of the extracurricular activity in this respect may diminish over time. All participants who completed the extracurricular activity believed that it should be re-run and felt that it should be incorporated into the curriculum.

Responses gathered from the non-completers group suggests that their knowledge of BIM is shallow compared to the completers. They dropped out because they could not allocate time for the extracurricular work. Further insights were gained anecdotally from informal conversations with some of the non-completers group, which provided a fuller picture of the reasons for the high dropped out rate. Students in this group felt that either the extracurricular did not meet their expectation, they lack the support of their tutors and lecturers and/or tutors misinterpret what BIM is and hence giving incorrect guidance/advice to students.

The online focus group study revealed several reasons why staff got involved in BIM and the extracurricular activity. Participant 1 stated that the interest in BIM comes particularly from their students who feel that this is a good opportunity to enhance their employability skills. Participant 2 also suggests that their part time students were particularly interested in BIM as their company is in the process of up-skilling their workforce to meet the BIM requirement set by the UK Government. Participant 3 added that exposing students to BIM collaborative working also allow students to understand the current limitation in the traditional silo practice in the construction industry and to be aware of the positive way forward in overcoming this challenge by the implementation of BIM. Staff felt that the key advantages of the BIM extracurricular activity were that it allows students from various disciplines to work

together and share their expertise in overcoming a problem. They also felt that it is crucial that they are provided with formal training to assist students in the use of BIM and multi-disciplinary teamwork with each other. They were also encouraged to share responsibilities of BIM implementation within the university. Virtual collaboration was highly recommended, as both full time and part time students would benefit from the BIM collaborative working.

CONCLUSION, LESSON LEARNED AND RECOMMENDATION

To fill the gap in the literature, this case study presents the perspective and experience of participants' in the BIM collaborative working extracurricular activity carried out over the second semester of 2013/2014 academic year. The approach in this research helped us understand and convey the complexities of implementing BIM collaborative working extracurricular activity within a higher education environment.

The most significant lesson learned from this research suggests that students who successfully completed the extracurricular agree that they have gained a better understanding in the way different disciplines operate. The extracurricular activity also provided them with more confidence in using BIM specialist software and working collaboratively in a multi-disciplinary team. However, students feedback stated that not all of the skills that they have obtained from the extracurricular activity were applicable to their final year. This is true especially in regards of the teamwork experience, where it tends to be in the form of interdisciplinary rather than multi-disciplinary. It is important to note that there's been high drop-out rate in this extracurricular activity and that this extracurricular activity may not entirely be viable in its present form.

Feedback from the non-completers group suggests that they dropped out because they could not spare the time for the extra-curricular work and that their knowledge of BIM was lesser compared to the completers. This finding enhanced our understanding on the importance for students to complete the extracurricular in order to obtain any benefit from it. Lessons learned from the staff online focus group suggest a strong consensus in the need to continue providing BIM experience to students (both in terms of experience in using BIM softwares and the multi-disciplinary teamwork environment). All staff members should be trained in the future use of the technical software and in managing multi-disciplinary teamwork so that they will be able to provide correct guidance and full support to all students.

The view gathered from the completers group highlighted the benefit of running the extracurricular over the entire of second semester as it allow students to gain project management skill, something that can not be entirely fulfilled in a shorter duration extracurricular activity. Response gathered from most students suggests that they would like this extra-curricular activity to be re-run in the near future with the long term view to embedded it in the formal curriculum. Implementing BIM fully into the curriculum will also ensure that all students are able to experience and benefited from it fully.

Despite the good response to the research from participants who completed the extracurricular activity and staff members, it is important to highlight some of the limitations of the research. The challenge and limitation of this research lies in the low response rate from students within the non-completers group. This means that the research and lesson learned could potentially be biased. However, anecdotal evidence gathered through informal discussion with some of the non-respondents in this non-completers group did suggest a similar answer to those non-completers students who responded. To improve the response rates in the future, the questionnaire will be made available online so that the survey is easy to take and return. It is also important to note that the limitation in implementing a single case study approach means that the outcome of this research is unique and hence cannot be generalized.

For BIM implementation to be successful, full support from other colleagues within the particular university would be essential. There is also the need to identify strategy in managing multi-disciplinary teamwork and in contributing knowledge to the project based on students' own expertise in their subject.

Following an increase of interest and request from current second year students, this year's extracurricular activity ran again for 11 weeks. The programme has been slightly revised based on lessons learned from the previous activity. The author hopes to collate data from this year's activity upon completion for further research study. The long term aim is to incorporate BIM collaborative working into the curriculum in the form of a shared design project module that can be implemented in all architecture, engineering and construction courses, where students from various disciplines and expertise would be able to meet and work together on a given project in a multi-disciplinary environment.

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