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ENHANCING THE GRADUATES' EMPLOYABILITY AND CAREER DEVELOPMENT THROUGH BUILDING INFORMATION MODELLING INTENSIVE TRAINING

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ABSTRACT

Building Information Modelling (BIM) is an emerging technological process which highly promotes a better collaborative working environment in the Architecture, Engineering and Construction (AEC) industry. It is essential that the Higher Education (HE) sector innovates its education system to integrate between different disciplines in the AEC industry to encourage the adoption of BIM. In conjunction with this, BIM Intensive Training was conducted for a selected number of final year undergraduate students at Universiti Teknologi Malaysia. They were assigned a real time construction project, utilizing BIM software applications for model authoring, model review, 4D modelling and project coordination. It was observed that the participants were able to overcome various challenges through information sharing and team collaboration. A BIM coordination workflow was produced during the training to assist them in organizing their work. Although their existing knowledge of BIM and their skills using the software applications were quite limited, they were capable in learning expeditiously as the assignment provided them with real-world problems. A year after the training, more than half of the participants agreed that the training had helped them to secure their employment and excel in their current involvements in BIM-based projects. However, due to the current scenario many firms are yet to embrace BIM, there are participants who could not utilize the training. Hence, the establishment of a dynamic and continuous collaboration between professionals and HE sector is the way forward in transforming the traditional structure of AEC industry into a more collaborative and technological approach.

Keywords: Building Information Modelling, Collaborative working, Education

1. Introduction

The Architecture, Engineering and Construction (AEC) industry has evolved into a more complex process, channelling numerous information throughout the whole lifecycle of a single construction project which involves various construction parties and stakeholders. Building Information Modelling (BIM) is the emerging technological trend in the AEC industry to accommodate the data complexity in a project (Succar, 2009) and becoming more prevalent for information exchange and sharing (Eastman et al., 2011). Although BIM has no single satisfactory definition until now, BIM could be explained in three

aspects, namely, the digital representation of a building, an object-oriented three-dimensional model, and a repository of project information (Miettinen and Paavola, 2014).

BIM has led to the dependency on technological usage to manage data for delivery and collaboration between construction parties. BIM technology and software applications could be considered as having a symbiotic relationship, where the software applications used in AEC industry could only be developed parallel to the development of BIM technology, while the implementation of BIM in a construction project could only be successful by employing suitable software applications.

Presently, there are various software applications being developed in the market to support the implementation of BIM in the AEC industry. These software applications are categorized according to their functions, for instance, authoring, analysis, construction management, quantity take-off and estimating, scheduling, and file sharing collaboration (BIMForum, 2018). Examples of software applications for authoring are Autodesk Revit (Autodesk, 2018a) and ArchiCAD (Graphisoft, 2018), while for construction management are Navisworks Manage (Autodesk, 2018b) and Tekla Structures (Tekla, 2018).

As the implementation of BIM in AEC industry is rapidly increasing, it is imperative that the construction players possess high proficiency in BIM and competence in using relevant software applications. It is equally important that the construction players break through from their own silos to create a better collaborative working practice through the implementation of BIM. The main reason behind this situation is that the current education practices rarely adopt BIM in the academic teaching and learning process, where students from various AEC disciplines learn in separate departments without much integration between the disciplines (MacDonald, 2012). Hence, creating a collaborative education in the HE sector is an optimum solution to produce better construction practitioners. This paper presents a study conducted on participants who were involved in BIM Intensive Training which adopted a collaborative education to investigate the impact on the graduates' employability and career development.

2. BIM in Education

Sacks and Barak (2010) and McGraw-Hill (2012) recognized that the main constraint in implementing BIM in AEC industry is due to the limited number of trained BIM personnel. On that account, HE sectors around the globe have taken initiative to integrate BIM in the curriculum through either being include in the undergraduate core curriculum or as an elective course for the students (Ozcan-Denis, 2016). A variety of pedagogies are suggested, applied and tested to successfully instill BIM knowledge to the students.

Based on the thorough analysis done by Barison and Santos (2018), BIM is integrated in the HE learning through four types of courses – single course, intra-course collaboration, interdisciplinary collaboration and distance collaboration. These courses were selected based on the BIM proficiency levels (BIMPL) to be achieved in a curriculum. For the introductory BIMPL, single courses are normally executed to develop skills in modelling and facilitating BIM design. Single courses are also chosen for intermediate BIMPL to develop analysing skills whilst improving modelling skills. Collaboration courses are suitable for advanced BIMPL to create BIM managers.

In many universities, BIM courses are introduced at the beginning of the programme. Milwaukee School of Engineering introduces the basic of technical skills in using AutoCAD and Autodesk Revit in a series of lectures and workshops (Ozcan-Denis, 2016). Another university in United States also integrates the introduction of Revit software application in the Construction Management programme (Faust, 2016). While these universities focus on the designing aspects, Brigham Young University has elevated the conventional cost estimating course by incorporating model-based quantity take-off activity, clash detection activity and project planning through BIM model into the existing curriculum (Miller, 2016). Vlasek (2016) argued that this type of pedagogy does not support learning continuity for the students in acquiring deep understanding of the real implementation and benefits of BIM process.

Therefore, instead of integrating BIM into AEC courses, it was suggested that BIM-based curricula should be developed where construction knowledge is fused into these curricula. In this approach, technical skills in using BIM software applications will be taught during the 1st year of the programme, construction management courses during the 2nd year and lastly interdisciplinary collaboration during 3rd and 4th year of the programme.

Collaborative education is highly encouraged to be applied in the BIM curriculum, for instance, in Norway, Civil Engineering students were given the task to virtually experience the construction process by modelling and being assigned into respective roles such as client, architect, engineers and contractors to practice collaborative working (Lassen et al., 2018). This was incorporated at the very early stage of their learning programme. A similar approach was introduced in China (Zhang et al., 2018) to combine BIM learning modules with Team-Based Learning pedagogy. Both studies were proven to be successful through the positive feedback from the students.

To encourage the adoption of collaborative education using BIM, a framework called IMAC was developed (Shelbourn et al., 2016) which incorporated the Bloom's taxonomy of learning (Bloom, 1968) and further development of Bloom's taxonomy by Krathwohl et al. (1964). This framework consists of four stages, namely, Illustration, Manipulation, Application and Collaboration. In the Illustration stage, the students will be taught in separate disciplines on the introduction of BIM. Next, the Manipulation stage will expose the students on how to interact and manipulate any existing BIM models. They will learn the basic skills in using relevant BIM software applications at this stage. In the Application stage, the students will apply the knowledge and skills acquired in the previous stages to solve discipline-related problems. Lastly, the Collaboration stage, students from different AEC disciplines will work together in a joint project to collaborate and coordinate their work.

In order to succesfully educate BIM for the AEC students, it is important to select the most appropriate BIM educators with competent BIM knowledge and skills (Angel, 2016). Industry involvement is the most suitable approach in ensuring this in which construction professionals are involved in a BIM curriculum. This was reflected in BIM for construction management course in an institution where Contractors were invited as guest lecturers and also facilitated in coordination meetings (Liu and Berumen, 2016). In another institution, industry was involved in a greater extent, in which hands-on collaborative activities were carried out with industry's support through case studies (Maghiar, 2016). These case studies acted as the medium to bridge the technological solutions such as software applications with their abilities to solve industry-based problems and challenges.

Besides industry involvement approach, it is also effective to educate BIM through project-based learning. In United Arab Emirates University, this methodology was applied for students to learn building construction while acquiring skills in Autodesk Revit (Ferrandiz, 2016). This had led to better visualisation and understanding of building construction in a BIM technology environment. Meanwhile, HE instutions in Ireland intercollaborate to promote BIM education. Through a study done by Hore et al. (2016), it was discovered that project-based learning is one of the approach used in institutions to cultivate BIM knowledge and skills in AEC students.

Pairing project-based learning process with collaborative BIM education along with industrial involvement is proved to be a feasible approach for BIM curriculum as discussed by Liu and Berumen (2016) for a digital project coordination class. In this course, students were required to coordinate building elements such as architectural, structural, mechanical and electrical and fire sprinkler system based on a project case. They were required to collaborate between different design disciplines and conduct coordination meeting while being facilitated by industry participants who shared their experiences in BIM-based projects.

In Malaysia, education system is the main catalyst in widening the adoption of BIM in construction projects (Mamter, 2018). Although HE institutions are aware with the importance of BIM education, it is imperative that HE institutions carry out more

concentrated efforts to become academically ready for the integration of BIM into the academic programmes (Yusuf et al., 2017). Collaboration between the industrial practitioners and HE institutions need be done more vigorously to help academicians in guiding the students and providing access to BIM-based project information.

3. Methodology

BIM Intensive Training was conducted in August 2016 for a duration of two weeks at Universiti Teknologi Malaysia. It was participated by 23 final year undergraduates consisting of six Bachelor of Science in Construction students, twelve Bachelor of Quantity Surveying students and five Bachelor of Science in Architecture students.

This training was conducted through an industry involvement approach and project-based learning process. A BIM consultant conducted the training and facilitated the participants in carrying out their tasks. A real time construction project consisting of drawings and contractual documents were provided by a contractor company which also assisted the participants throughout the learning process. During the training, the participants utilised Autodesk Revit 2015, AutoCAD 2014, Naviswork Manage 2015 and Microsoft Project 2013 for model authoring, model review, 3D coordination and 4D modelling. At the end of the training, the participants presented their outcomes to the contractor of the project.

Experiential learning process was applied in this training to ensure that learning was grasped through the process rather than the outcomes. This was highlighted by Kolb and Kolb (2009) in which HE sector should focus on engaging students in the process to enhance their learning capabilities. The students' feedback on the effectiveness of their learning process is the most important criteria to be considered in an experiential learning approach. This approach was applied in a study conducted by Wu and Hyatt (2016) where the students were asked to share their experiences through a survey done after the learning process.

Throughout the training, the participants were observed on how they carry out the tasks, their team management and problem-solving techniques. Observation method was the most suitable method to be used to descibe the behaviours and events (Maxwell, 2005). Furthermore, interference during the learning process could be avoided through this method. Aligned with the experiental learning process, a telephone survey was conducted a year later among the participants to identify the impact of the training to their employment and the application of BIM in their working environment. The study also inquired on their current employment, the waiting time duration from when the training ended to their employment and their involvement in BIM projects in the company, as well as whether the training had helped them to start their career. The responses from the survey were then analysed.

4. Results & Discussion

In the training, the participants were given definite project objectives, namely, to visualise construction design and analyse the constructability, to identify clashes in construction design for 4D BIM, and to ensure construction processes are more effective. To achieve these project objectives, the participants worked together as a team led by a BIM Manager appointed amongst the participants while being guided by the BIM consultant and contractor. They were able to produce a BIM Coordination workflow to organize their work. The workflow is as shown in Figure 1.

The workflow was produced to act as a guideline and checklist for the participants to conduct their task while coordinating among their team members. As shown in Figure 1, they received actual drawings from contractor in .dwg file format, compatible for AutoCAD software and incomplete BIM model in .rvt file format, compatible for Autodesk Revit software. With this data, the BIM Manager created a central model to be accessible for all team members and distributed the work based on AEC

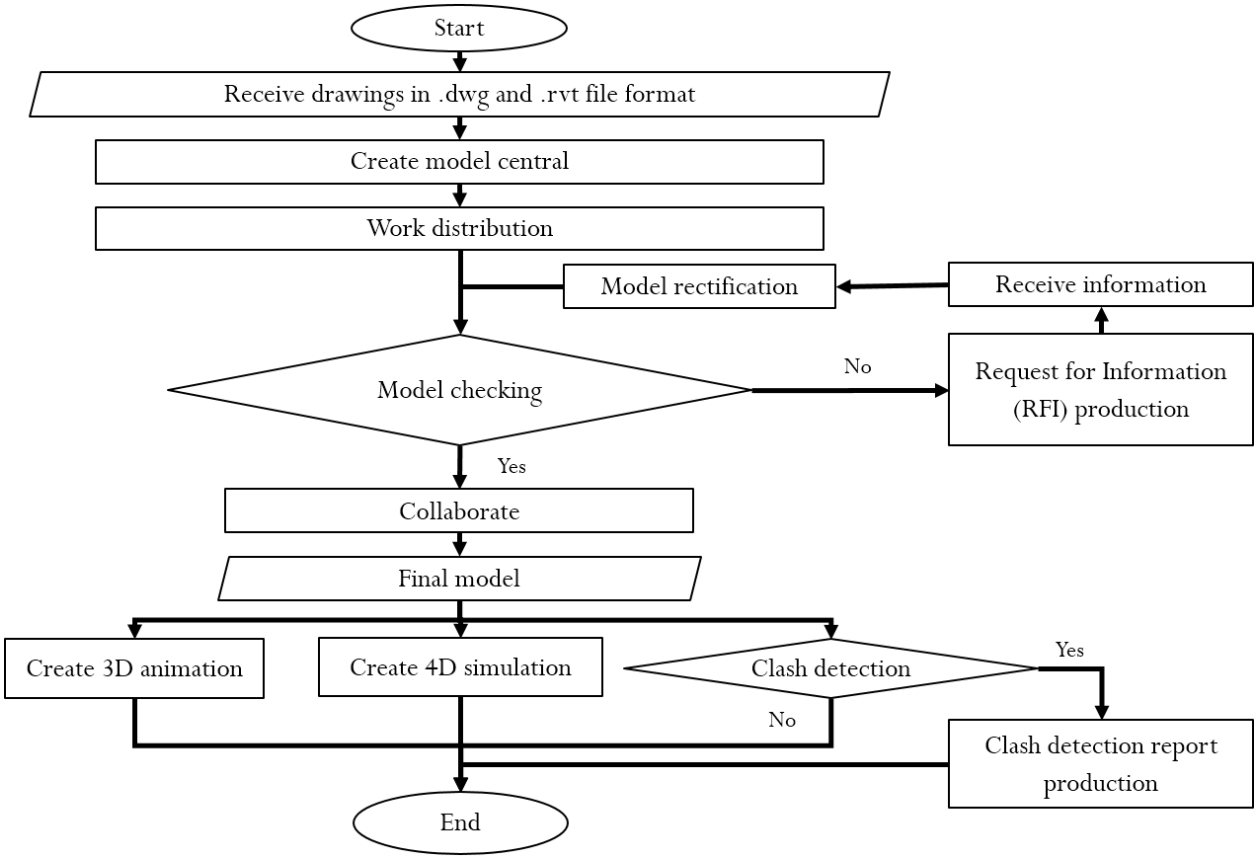

Figure 1 BIM Coordination Workflow

disciplines, namely, architectural, structural, and mechanical and electrical elements. The team then checked the model for any discrepancy in the model with the information in the drawings and also checked for any incomplete information in the drawings. Based on this analysis, they produced a Request-For-Information (RFI) document to be addressed to the contractor. They discussed with the contractor on this RFI document daily throughout the training. After receiving the information, they then rectified the model and repeated the process of model checking. At the point where the model is adequate, reliable and correct, the team members collaborated their models of different work disciplines into the central model to finalise the model. Based on this final model, they created 3D animation to visualise the construction, 4D simulation to analyse the constructability against time duration, and conducted clash detection activity. These activities are conducted to create better and effective construction processes. The model and relevant documents were compiled and presented to the contractor.

Throughout the training, it was observed that the participants were faced with challenges on how to perform their tasks. The most prominent challenge was their low existing knowledge and skills in Autodesk Revit and Naviswork Manage software applications. Therefore, huge efforts were required from the participants to quickly learn the software while carrying out their tasks. In addition to this, their knowledge in BIM management, coordination and collaboration were also limited. Fortunately, since they were equipped with hands-on training and guidance from BIM consultant, they could grasp the knowledge within a short period of time. Another challenge was that the network could only cater for a limited number of users causing difficulties in communicating and exchanging information among team members. Nevertheless, the team members found a solution by creating copies of the central model and working in small groups based on the work disciplines and further collaborate the models to become a final model.

At the end of the training, it was observed that the team members have a good understanding of BIM process in a project and an improved knowledge in the construction technology and processes. Their communication and team management skills were observed to have improved since the beginning of the training. They also acquired and improved their technical skills in using Autodesk Revit, AutoCAD, Naviswork Manage and Microsoft Project which are beneficial for their employment. Meanwhile in the Contractor's perspectives, they were highly satisfied with the outcomes produced by the participants.

A year after the training, a telephone survey was conducted with the participants to gather their feedback on the training. Based on the findings, 21 out of 23 participants are working in their related fields as Quantity Surveyors, Project Engineers, BIM Engineer, BIM Modeller, Assistant Architects in various companies comprising of Developer, Contractor firms and Consultant firms. For other participants, one of them are currently pursuing in post-graduate studies while another is self-employed. The participants who are employed in their related fields were able to secure their employment in less than a year after the training. The time duration from the end of the training to their employment is as demonstrated in Figure 2 in which majority of them (17 people) managed to be employed within less than 3 months.

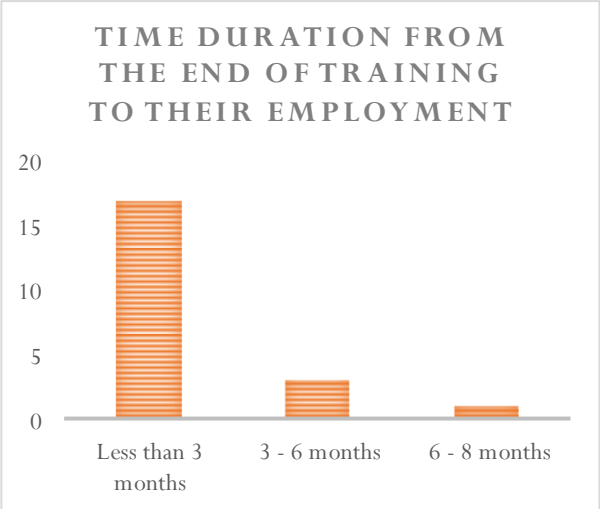

Figure 2 Time duration from the end of training to their employment

Next, the participants were asked on their involvement in BIM-based projects and whether the training had helped them in starting their career. The responses are as shown in Figure 3 and Figure 4 respectively in which only 9 participants (39%) are currently involved in BIM-based projects and 13 participants (57%) claimed that the training had positive impact on their career while 10 others (43%) stated that it did not help for their career. Three main reasons were identified from the survey for the participants who claimed that BIM training is a stepping-stone for their career while a single reason was identified from the group of participants with the opposite opinion. Each reason is presented below along with a few examples of quotes indicating the reasons.

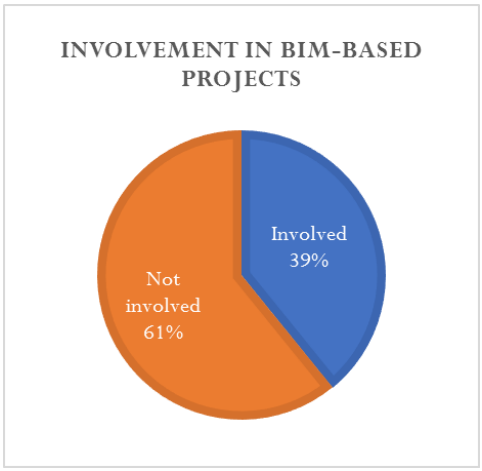

Figure 3 Involvement in BIM-based projects

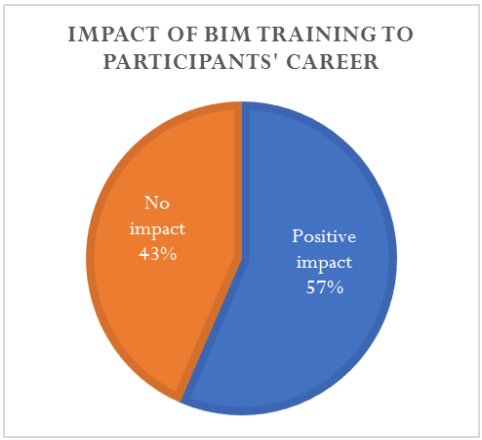

Figure 4 Impact of BIM Intensive Training to participants' career

Nine participants stated that BIM has helped them in starting their career because they are directly involved in a project which applies BIM. Most of them are employed in Quantity Surveyor Consultant firms and Architect Consultant firms. Their scope of works mainly include modelling, quantity take-off, cost estimating and construction planning. Since they were equipped with basic knowledge through this training, they were able to contribute more in the projects. For example, a participant (Participant-18) stated that, "*It* [BIM training] *gives me one step ahead to prepare estimate and measurement. Since my superior did not really guide me, I could explore and gain knowledge from the model, which most of my colleagues were not sure on how to extract.*"

Another reason highlighted by the participants who agree on the positive impacts of BIM training is that they were able to secure the job application during interview. The participants had taken full advantage of their experiences in the BIM training for their employment. The employers were impressed with their efforts to learn more than the academic programme had offered. Since the production of graduates with BIM expertise are very low (Yusuf et al., 2017), the participants were able to secure their employment compared to other graduates. This is proven when a participant (Participant-20) claimed that, "*Yes. BIM training is an extra point when applying for job. BIM is on demand in job market. Employer doesn't hesitate to employ graduate with BIM training.*Another participant (Participant-08) revealed that, "*Although my company* [the company in which she is employed to] *is not currently involved with any BIM project, it* [BIM training] *definitely helps during the interview as it gives extra values to me and give better impression of myself to the company.*" This shows that while BIM is not fully adopted in the construction industry in Malaysia, the industrial practitioners are becoming aware on BIM and prefer to employ graduates with BIM knowledge.

Although introduction to BIM was included in Information Technology in Construction subject, the students could not visualise the adoption of BIM in a construction project. Through this training, the participants were introduced to the right implementation of BIM in a real-time construction project. The participants were given a new perspective in understanding the body of knowledge in BIM while gearing themselves up with relevant skills to execute BIM-based projects in their working environment. This training also provides them with awareness on the importance of collaborative working in BIM environment. A participant (Participant-09) stated that, "*This training helps in providing an overview of how BIM can be applied in a project and triggered my interest to focus on this area for my research.*"

The survey revealed that 43% of participants claimed that the training did not help them in their career because they are currently not involved in any BIM project. Majority of them are working in Contractor companies. A participant (Participant-01) claimed that, "*No. My company* [the company in which she is employed to] *is a sub-contractor company which do not apply BIM in any project.*" The limited knowledge on BIM by the companies also hinder the positive impact of the training, for instance, a participant (Participant-04) stated that: "*No. The company* [the company in which he is employed to] *doesn't even know what is BIM.*" This is due to the low adoption of BIM in Malaysia which is at the rate of 10% compared to United States, United Kingdom and Singapore (CIDB, 2015). This could also be reflected on the previous interview questions whereby 61% of the participants are not involved in any BIM-based project.

5. Conclusion

Project-based learning process and collaborative industrial involvement had undoubtedly benefit the students in acquiring necessary knowledge and skills in modelling, analysing and coordinating BIM-based projects. It had been an advantage for the employment of the participants as well as giving leverage to participants who are involved in BIM-based projects. The training provided them with extensive introduction of BIM working environment, equipped with additional knowledge and skills which are currently not adapted in the academic programmes. The collaborative working environment adapted in this training had encouraged the participants to work beyond their own disciplines to achieve the main objectives. It is proven that the participants could apply their experiences in the training for their career development.

Similar trainings could be carried out in the future with further improvements. As hardware problems had arose during the training in which one network could not cater for all participants, this issue need to be resolved before conducting another training. This could be done by reducing the number of participants in a training or by separating disciplines according to network and having a coordination meeting daily to ensure the collaborative working environment. Another improvement that could be done is to have learning continuity as suggested by Vlasek (2016). Instead of conducting a training at the end of the students' education path, such training could be conducted at an earlier stage followed by phases of trainings at the intermediate and end of their programme. This training is one of the initial effort to integrate BIM education in the HE curricula in Malaysia. Industry involvement in the training helps to establish good relationship between industry and HE institution, subsequently, opens the opportunity for internship programme in BIM-based projects in the future.

However, there are still many firms in Malaysia which are yet to embrace BIM and still grounded to the conventional ways. This is reflected through the participants who are not involved in any BIM projects. Hence, future works should also concern on the establishment of a dynamic and continuous collaboration between BIM-based companies and Higher Education Institutions. This will eventually transform the traditional structure of AEC industry into a more collaborative and technological approach.

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