TEACHING BIM IN A MULTIDISCIPLINARY DEPARTMENT

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Abstract: Universities need courses to reflect what is happening in the macro environment. With Building Information Modelling (BIM) being mandated for all UK Government projects from 2016, many within built environment industries are already adopting BIM working methods. It is therefore essential that students are equipped with the skills and understanding of BIM concepts to be relevant and achieve employment in a rapidly changing construction industry. In order to achieve this BIM needs to be added to the curriculum. One of the reasons that the UK government wants to introduce BIM is that it allows collaboration across the disciplines in construction. In literature there have been a number of examples of the approach taken by Universities but these focus on the way it is taught rather than the mode of delivery. This paper examines lecturer, employer and student perceptions of the optimum way to teach BIM in a multidisciplinary department. It indicates that BIM teaching improves student employability. The mode of delivery preferred overall for BIM teaching is via standalone modules and in collaboration with other built environment courses dealing with both theory and software. The ranking of separate modules for theory and software was very low indicating the preference for both to be taught in a single module.

Keywords: BIM, Teaching, BIM Pedagogical aspects, Student Employability.

1. INTRODUCTION

Snook (2009) provides the official definition of Building Information Modeling (BIM) as a *"digital representation of physical and functional characteristics of a facility creating a shared knowledge resource for information about it forming a reliable basis for decisions during its life cycle, from earliest conception to demolition."* Kymmell (2008) shows that the idea behind an intelligent 3D BIM model is to use a virtual environment to imitate a construction project using computer software. This simulation is not only geometric but contains elements of the specification including design life, costing and purchase information which allows management of the facility from concept to demolition (Bin and Yu, 2010). This produces many benefits and has led to the UK government setting a target of 2016 for BIM adoption on all government projects (Efficiency and Reform Group, 2011). The BIM Industry working group (2011) suggests BIM adoption will increase productivity and ensure that the construction industry is more refined. However, the implementation of BIM in the construction sector is being delayed by the absence of sufficiently trained BIM personnel (Becerik-Gerber et al., 2011). Universities are seeking to address this issue, especially with studies, such as that from Wu and Issa (2013), showing that BIM knowledge is inextricably linked to employability. This paper examines this from the perspective of students, academics and employers.

To construct a project, input is required from a variety of specialisms including architects, architectural technologists, engineers, and quantity surveyors. Baiden et al (2006) consider the typical construction project to be a collaborative venture involving these specialisms coming together to form "*the construction project team*". BIM allows this collaboration to take place in a virtual environment. Arayici et al (2011) confirms that BIM allows collaboration transcending organisational boundaries resulting in enhanced project performance. This paper examines the appetite amongst employers, university staff and students for a cross discipline approach to teaching BIM.

1.1 Literature relating to BIM implementation by Universities

Kymmell (2008) identified barriers to imbedding BIM in the curriculum. Three categories were specified:-

1. Capability in the software aspects relating to learning and using BIM software;
2. Confusion as to the strategic and process issues and;
3. Changing the academic environment to accommodate implementation.

A lot of research has focussed on BIM software and the government construction strategy. However, little has been published on the environment that BIM should be taught in. This research is set in the context of a university which has adopted a modular system of teaching and the paper explores for the first time student, staff and employer perceptions of the best mode of BIM teaching delivery.

1.2 Literature relating to employment issues relating to BIM

Literature has provided evidence of BIM impacts across the full spectrum of built environment disciplines. Poerschke et al. (2010) were able to demonstrate in literature a collaborative BIM course that brought together students from six different disciplines from three academic departments to experiment with BIM. Thomas et al (2013) developed a link with industry that allowed students from Architectural Technology and other construction related programmes to work with real information from a live project. The remainder of literature focused on individual modules in specific disciplines. Sacks and Barak (2010) changed an engineering graphics module to implement 3D modelling in civil engineering. In structural engineering, Barham et al (2011) used BIM in concrete design. Sustainability and environmental design have been incorporated via BIM by Hyatt (2011). Peterson et al. (2011) linked BIM software to project management tools in construction engineering project management courses. For the first time this paper seeks to show with empirical data whether the single module model or integrated model across a number of courses is preferred by students, staff and employers.

2. RESEARCH METHOD

The study used Limesurvey™ to gather survey data via a managed PHP interface to a MYSQL database. The study was conducted in three parts. The first collected data from 246 final year students in the School of the Built Environment. In total 144 responses were received providing a response rate of 58.53%. Rubin and Babbie (2009, pg 117) consider a response rate of over 50% to be 'adequate' for the purposes of analysis.
Responses from the various courses involved are provided in Table 1.

Table 1 Breakdown of student responses

Course	Number of responses	Percentage of Responses
Architectural Technology	31	21.53%
Quantity Surveying	42	29.17%
Civil Engineering	38	26.39%
Building Engineering & Materials	5	3.47%
Construction Engineering and Management	28	19.44%

The second section of the study collected data from lecturers from both the Belfast School of Architecture and the School of the Built Environment. Of the 44 lecturers contacted, 24 responses were received. This equates to a response rate of 54.54% again above the "acceptable" limit for validity and reliability purposes in Rubin and Babbie (2009).

The third section of the study collected data from employers that employed placement students and graduates of the University of Ulster. There were 85 organisations contacted. Three opted out commenting that they did not have the expertise to complete the questionnaire. There were 34 completed responses received a 41.46 response rate. This is a limitation in relation to validity and reliability (Rubin and Babbie, 2009) but the qualitative aspects are included and the basic statistics regarding the teaching options for comparative purposes.

3. FINDINGS

3.1 Findings on the impact of teaching of BIM on students of construction courses

While the strategic aspects of BIM have been introduced to all the taught courses, practical elements have not been introduced to all. Currently the responses show that 45 (31.25%) students had practical experience of BIM through their course and 99 (68.75%) said they had no practical experience. Table 2 indicates the respondent's considerations on aspects of BIM. The findings indicate that students considered BIM software easier to use than 2D CAD programmes. Another positive was that they considered it gave them a better understanding of the construction / detailing process than the 2D option. The impact BIM adoption has on other construction modules should not be minimised. Students agreed that the learning achieved through BIM modules has proved useful for other construction modules. Furthermore, students acknowledge that BIM exposure has enhanced their self-confidence in applying for a job.

Table 2 Impact of Teaching BIM on Courses

Question (Scale 5-Strongly Agree to 1 – Strongly Disagree	Arithmetic Mean	Standard Deviation
Is BIM software easier to use than 2D CAD programmes	2.96	1.04
BIM provides a better understanding of the construction/detailing process	3.18	1.11
BIM has proved useful for other construction modules	3.14	1.18
BIM knowledge has enhanced my self-confidence in applying for a job	3.24	1.13

3.2 Findings on Lecturers perspectives on the teaching of BIM

Academics strongly support the perception that use of BIM will increase over the next five years. This is evidenced through their ranking, providing an arithmetic mean of 4 and a standard deviation of 0.98. They support the hypothesis that advanced BIM theory knowledge will be important to graduates over the next five years with an arithmetic mean of 3.54 and a standard deviation of 0.88. This increases to an arithmetic mean of 4.13 and a standard deviation of 0.9 for introductory BIM theory knowledge. They also support the hypothesis that advanced BIM software knowledge will be important to graduates over the next five years with an arithmetic mean of 3.46 and a standard deviation of 0.93. This increases to an arithmetic mean of 3.96 and a standard deviation of 0.81 for introductory BIM software knowledge. They were further asked to identify how important they considered having BIM as a core curriculum component would be for graduates getting employment on graduation. This produced an arithmetic mean of 3.79 and a standard deviation of 1.02. These figures emphasise the importance of BIM teaching to the employability of students. They also emphasise the need to have a BIM component evident in each course to provide the knowledge required to meet the needs of industry.

3.3 Findings on Employers perspectives on the teaching of BIM

Employers recognise the impact BIM will have in the Architectural, Engineering & Construction (AEC) industry within the UK and Ireland over the next 5 years as they ranked its importance with an arithmetic mean of 4 on a Likert scale of 1-5, 1 being little importance and 5 of vital importance with a standard deviation of 0.94. They also strongly support the perception that use of BIM will increase over the next five years. This is ranked with an arithmetic mean of 4.14 and a standard deviation of 0.98. This is a higher rank than the academics indicating that those at the “coal face” are more aware of the importance of BIM adoption. They support the hypothesis that advanced BIM theory knowledge will be important to graduates over the next five years with an arithmetic mean of 3.79 and a standard deviation of 0.95. This increases to an arithmetic mean of 4.21 and a standard deviation of 0.84 for introductory BIM theory knowledge. They also support the hypothesis that advanced BIM software knowledge will be important to graduates over the next five years with an arithmetic mean of 3.76 and a standard deviation of 0.82. This increases to an arithmetic mean of 4.24 and a standard deviation of 0.78 for introductory BIM software knowledge. They were further asked to identify how important they considered the adoption of BIM technology in education as a core curriculum component would be in their organisation offering placement/graduate positions to students with BIM skills in the next 5years. This produced an arithmetic mean of 3.79 and a standard deviation of 0.98. These figures are identical to those from an academic standpoint and only further emphasise the importance of BIM teaching on each course to the employability of students.

3.4 Findings on opinions on teaching methods of BIM on courses

Table 3 indicates the rankings for the way in which students, lecturers and employers see the teaching of introductory and advanced level teaching within a University context. It can be seen from the findings that the overall (O/A) preferred mode of delivery for BIM modules for both introductory and advanced BIM teaching is that they are *Standalone modules and in collaboration with other built environment courses dealing with both theory and software.* The top three overall rankings are the same for both introductory and advanced teaching. The collaborative and multidisciplinary aspects of BIM are therefore clearly identified. The findings indicate that academics and employers especially realise the importance of this aspect of BIM. Students also acknowledge this but wish to specialise in their own discipline which is the reason that they chose to do the course they are on, therefore the ranking for a collaborative module across the disciplines drops into second position. The rankings also indicate that theory and practice should be taught together. There is very little support for either the theory or software aspects of BIM being segregated and taught separately. Therefore a holistic approach to teaching BIM should be adopted on University courses. *A* Standalone module within a specific Discipline Area dealing with both theory and software ranked second overall for both introductory and advanced teaching of BIM. Of note is the difference in ranking from academics. They ranked introductory and advanced BIM teaching differently in this model of delivery with the introductory dropping into third place behind *Not as a standalone module but integrated within other modules within a specific discipline area*. This indicates that they consider the material applies over a wide variety of aspects of construction and therefore should be taught with the relevant other material. However, when the advanced material needs to be taught they recognise that this is a specialist topic and should be taught as a separate module.

Table 3 Findings on way of Teaching BIM on Courses

Module Type	**% for Introductory Level Teaching**							**% for Advanced Level Teaching**						
	Students %/Rank		Lecturers %/Rank		Employers %/Rank		O/A Rank	Students %/Rank		Lecturers %/Rank		Employers %/Rank		O/A Rank
Standalone module within a specific discipline Area dealing solely with software	9.03%	4	0.00%	5	5.71%	5	5	11.81%	3	0.00%	5	2.86%	4	5
Standalone module within a specific Discipline Area dealing solely with theory	0.69%	9	0.00%	5	2.86%	6	7	0.69%	8	0.00%	5	0.00%	5	9
Standalone module within a specific Discipline Area dealing with both theory and software	38.19%	1	25.00%	3	20.00%	2	2	37.50%	1	29.17%	2	8.57%	3	2
Not as a standalone module but integrated within other modules within a specific discipline area	13.89%	3	33.33%	2	17.14%	3	3	11.11%	4	25.00%	3	8.57%	3	3
Standalone module and in collaboration with other built environment courses dealing solely with software	5.56%	6	0.00%	5	0.00%	7	6	4.17%	6	0.00%	5	2.86%	4	6
Standalone module and in collaboration with other built environment courses dealing solely with theory	2.08%	7	0.00%	5	0.00%	7	8	1.39%	7	0.00%	5	0.00%	5	8
Standalone module and in collaboration with other built environment courses dealing with both theory and software	22.22%	2	37.50%	1	34.29%	1	1	23.61%	2	41.67%	1	57.14%	1	1
I do not have an opinion	6.25%	5	4.17%	4	17.14%	4	4	8.33%	5	4.17%	4	17.14%	2	4
Other	1.39%	8	0.00%	5	0.00%	7	9	0.00%	9	0.00%	5	0.00%	5	10
No Answer	0.69%	9	0.00%	5	2.86%	6	7	1.39%	7	0.00%	5	2.86%	4	7

Two other options for teaching BIM were received from students were the provision of a *core module to teach basics while integrated through design modules* and that it should be *run in collaboration with CAD classes as they need to be shown the software. Classes on the theory of BIM are of little practical use. "Hands on" experience is essential*. Both of these options were received from a single student and therefore do not have much support.

4. CONCLUSIONS

With the UK government targets of 2016 already set, the findings of the study indicate that BIM teaching will become vital for students, academics and employers. There is a need for Universities to meet the needs of industry and produce graduates with a good standard of BIM knowledge. Not only is it essential to meet the requirements of industry but students considered BIM software easier to use than 2D CAD programmes and it gave them a better understanding of the construction / detailing process than the 2D option. Its wider impact on other construction modules should therefore not be minimised. Students, academics and employers all agree that the teaching of BIM has a positive impact on student employability. The preferred mode of delivery for BIM modules for both introductory and advanced BIM teaching is that they are *Standalone modules and in collaboration with other built environment courses dealing with both theory and software*, therefore acknowledging the collaborative aspects of BIM and making the teaching as close to the "construction project team" in practice as possible. The students chose a course to specialise in their own discipline therefore dropping the course specific aspect into second position. However, the views of employers and academic staff should prevail as the collaboration aspect of BIM has already been shown to be vitally important. Further work is required to determine the exact contents of the modules for teaching BIM but what is important according to the findings is that the theory and software elements should be taught together.

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