BIM: postgraduate multidisciplinary collaborative education

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Abstract

BIM technologies and processes are steadily increasing in the design and construction industry. The amount of undergraduate courses delivering BIM based applied and theory courses is also on the rise. These students will be entering a job market where their skillsets in digital modelling and collaborative practice will be in demand. However, existing AEC (architectural, engineering, construction) professionals are recognising the changes happening in the industry. Each domain is influenced and challenged by BIM. The traditional process and workflows will change as BIM adoption grows. AEC professionals are seeking out training and education courses to upskill. Perhaps the greatest challenge faced by professionals seeking to move their work to BIM is the conceptual move away from pushing data out to the stakeholders in a traditional detached procurement process in favour of bringing the stakeholders to the data in a collaborative process. Collaboration is not something that comes easy in a design and construction industry that has its roots in a division of intellectual effort over technical know-how going back over 500 years. For PG (postgraduate) students who have been taught in domain based silos then professionally educated within demarcation boundaries of one's discipline based on a hierarchical system of design responsibility, the idea of setting this to one side so that you open yourself to a collaborative process is a daunting prospect. Specialist education programmes must be developed to teach such professionals how to collaborate. AEC professionals can take full advantage of the technologies and the integrated collaborative process it promotes. This paper will report findings on a case study of postgraduate multidisciplinary collaborative learning module in the School of Multidisciplinary Technology's CPD BIM programme in the Dublin Institute of Technology.
Keywords: BIM education, BIM postgraduates, BIM multidisciplinary collaboration, BIM learning environments.

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1 Introduction

Tobin [1] states the long-term impact of any innovation is often not understood when it initially emerges, a fundamental transformation of design services also occurs as BIM models proved increasingly valuable for numerous uses beyond the mere drawings they made possible. Bruffee [2] had a theory that college and university teachers have been taught to think about what they know and how they know it drives the way they teach it. He states teachers can change the way they teach only by changing what they think about, what they know and about how they know it. In terms of collaborative learning it is legitimate to ask if the methods of teaching and learning currently used in higher education are suitable for a collaborative pedagogy. If one examines the current methods of teaching and learning in the built environment you see many references to "education silos" (Macdonald [3]), these tend to be proliferated by colleges, schools and departments. The individual lecturer who knows their subject well is not inclined to open themselves to areas where they are not experts and have to rely on a colleague's subject area. Educators can exist themselves in silos in terms of their own practice and follow a pattern by which they teach the way they were taught. Students too have expectations coming to college, They come from an education system which is predominantly traditional in its teaching and learning where the teacher stands in front of the class and delivers "knowledge" which they are expected to listen, note take, revise and rote learn. This paper investigates a methodology of teaching and learning which breaks away from the traditional and makes use of a constructivist paradigm which more closely aligns to work practice but in itself can influence further workplace education. A flipped classroom to foster creative and critical thought.

2 Literature review

2.1 Why the need for collaboration over cooperation in the design and construction industry

The design and construction process is by its nature highly dependent on interdisciplinary teamwork. The nature of this teamwork in traditional procurement has been at best cooperative, often enforced through binding contracts. Cooperation can be defined within the Built Environment as, individuals and or practise firms who exchange relevant information and resources in support of each other's goals to attain their own goal, In this case getting rewarded for their professional input. This cooperation is a contradiction by its nature and inevitably as is evidenced leads to conflict, leading to litigation. Collaboration on the other hand is working together in a joint intellectual effort to create something new in support of a shared vision. In terms of the built environment the group share the spoils and share the risk. Collaboration is a behavioural choice, as well as a cognitive capability [4]. This behavioural choice is often referred to within the BIM domain as a paradigm or culture shift. The key attribute of BIM project team (project-based organisation) is cross-functional and cross-cultural assembly

embraced by modernised technology (Hossain *et al.* [5]) while the major purpose of implementing BIM, is to attain a collaborative project delivery process by unifying people, process, and technology (Hardin [6]).

2.2 Educational culture change to teach a collaborative skill-set

Postgraduate students have been educated in domain based silos. The fundamental problem is that both the educational system and professional practice of the disciplines responsible for building design and construction are split into increasingly specialized and fragmented components – professional and knowledge "silos," within which architects, engineers, and construction managers fail to communicate and collaborate effectively (Vassigh [7]). Students will have been exposed to different methods of teaching ranging from didactic traditional lectures, problem based learning, lab-based demonstration, group activity or constructivist facilitator style. What these have in common is the individual assessment result from the effort reinforcing the individual nature of study. Postgraduates will enter into the workplace where there are demarcation boundaries of one's discipline based on a hierarchical system of design responsibility. In essence they will slip into a comfort zone of competencies and take on the cooperative methodological ethos. As a culture we are were ambivalent about turning anything over to anyone else. We are highly individualistic – there's positive reinforcement for not collaborating – where talent is centered on making a personal reputation collaboration will get the back of the hand (Hall [8]). It is a legitimate question to ask if traditional teaching methods are suitable for a collaborative pedagogy. Collaborative learning represents a significant shift away from the typical teacher centered or lecture-centered milieu in college classrooms (Goodsell *et al.* [9]). This learning is an active, constructive process that is inherently social. In collaborative learning situations, students create something new with the information and ideas. For postgraduate AEC professionals who seek to embrace BIM they will have to set aside their conceptions of education and professional practice and open themselves to learning about a collaborative process through a collaborative pedagogy. This can be a daunting undertaking. Educators must respond to the complexity of the task by developing specialist education programmes.

2.3 Collaborative learning in education and in the workplace

An examination of the NTL learning pyramid, Magennis and Farrell [10] indicates that the 3 highest rated teaching methods for student learning retention are group discussion, practice by doing and teaching from and by peers. All methods suitable for collaborative pedagogy. Blooms Taxonomy, Bloom and Krathwohl [11] refers to higher order thinking skills in the zones of analysis, synthesis and evaluation which match the requirements of QQI Level 8 [12] learning outcomes.

Collaboration is a purposeful relationship, collaboration describes a process of value creation that traditional structures of communication and teamwork can't achieve (Schrage [13]). New novel teaching methods must be developed that combine the higher order cognitive domains with the suggested higher rates of learning retention learning methods.

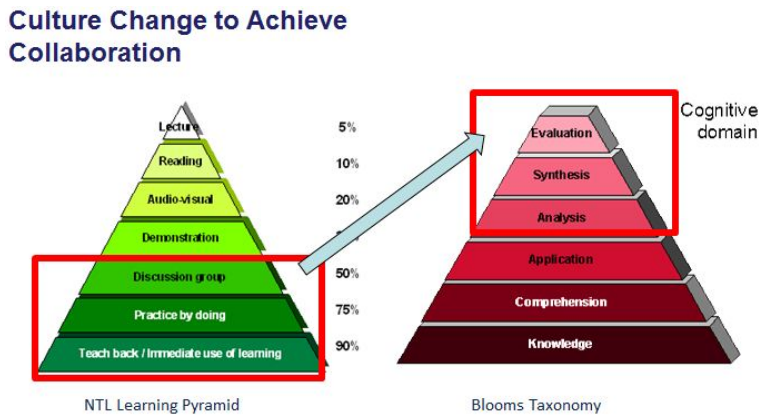

Figure 1: Matching retention to cognition and vice versa.

2.4 Reacculturation

Foundational and non-foundational education theories are two different ways of thinking about knowledge (Bruffee [2]). Foundational refers to learning as cognition. The cognitive understanding of knowledge is foundational because it assumes that there is a theory, a structure, beneath knowledge on which all knowledge is built. Non-foundational understanding of knowledge is an alternative to this traditional cognitive idea. It asserts that people construct knowledge from a variety of "languages" available to us. The knowledge is not absolute, it is local and ever changing, building up layer upon layer and is constantly reconstructing your knowledge. The school of thought called "non-foundational social construction" would believe that knowledge is a community project, interesting in terms of collaboration where the language is one constructed, owned and spoken by that community (Bruffee [2]). This is so prevalent in this age of instant and global communication that communities of collaborators are already all around us. Internet based gaming is an organic growing community to which there is a new "language" of developing knowledge. Moving and changing from foundational to non-foundational education is a process that Bruffee calls reacculturation. He defines this as a complex and painful process that involves the student or practitioner giving up, modifying or reconstructing the language, values, knowledge from the community they come from and become fluent instead in the language and so on of another community. This community is new, and the fear of the unknown can drive people back into their comfort zone so that collaboration gets distilled and loses out to cooperation. Cooperation is a failsafe but in essence a failure because no new knowledge is being generated just old knowledge regurgitated.

2.5 The nature of collaboration

Schrage states that there are two types of collaboration, Conceptual Collaborations and Technical Collaborations, technical collaboration seeks to solve the problem

the conceptual collaboration identifies. In a design and construction project the stakeholders will be active in both zones. The skillset that each brings to the collaborative will be called upon as the problem requires with each stakeholder assuming a lead role within their area of expertise developing what Fong calls Boundary Crossing leading to knowledge sharing, knowledge generation, knowledge integration to collective project learning (Fong [14]).

3 Methodology

A qualitative case study methodology has been used to examine both the teaching methods and the learners experience resulting from the module. A hallmark of case study research is the use of multiple sources, a strategy which can enhance data credibility. Case studies present data that is usually gathered through a variety of means including, but not limited to interviews, observations, audio and video data and document collection. The goal of collecting data through a variety of means is both to enhance the theory generating capabilities of the case, and to provide additional validity to assertions made by either the researcher or the participants in the case itself (Patton [20]).

The author used seven methods of data collection that were bound up with the student's collaborative learning activities.

1. Observation of collaborative groups in class;
2. Video recording of group collaborative meetings using Google Hangouts;
3. Recorded discourse on the group's website;
4. Reflective writing by the students;
5. Recorded discourse on Google +;
6. Assessment and presentation of group collaborative project;
7. Module end interviews of a sample cohort of students;

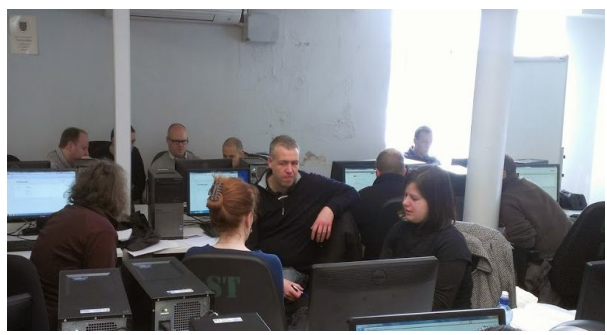

Figure 2: Collaborative groups in studio.

The aim of this research is to report findings from evidence provided from a multidisciplinary collaborative module that was part of a CPD diploma in BIM Technologies in the Dublin Institute of Technology. The collaborative learning was driven by a teaching pedagogy that aimed to promote a high level of cognitive learning and creation of new knowledge within the collaborative group.

Collaborative learning is rooted in a socio-cultural model of educational psychology described by Vygotsky [16]. The socio-cultural model focuses on how social interaction affects cognitive development, but rather than focusing on an individual's actions, the emphasis is on the role of interactions with others. Analysis of the data sets was carried out at project end. The data sets of the project and were compared, criticised and reflected upon.

3.1 The teaching method

The CPD module has a 10 week contact period with students attending on Friday evenings and Saturday mornings. Forty six students were split up into groups of 5/6 with as best as possible distribution of the domain specific professions in each group. It was necessary to provide the students with tools that would allow and enhance their collaboration, to create a "shared space". Shared space is the new dimension of BIM, collaboration it's a dimension embracing simulation, discourse and memory, stakeholders have equal access to the shared space where the shared space is used to create shared understandings. The shared space becomes a collaborative environment (Schrage [13]). The author chose to use the Google Suite of applications which are free to all who have a gmail address and a profile set up on Google +. Google Circles was used to create a group and class communication platform. Google Sites was used to create a group website to record the group's discourse on their learning journey. Google Hangouts was used for off campus co-located conference meetings. These video meetings were recorded and uploaded via YouTube on to the group websites. Google Drive was used to store and share documents. The other piece of technology required for the BIM collaboration was a BIM Server to provide for the workshare central model. The College of Engineering and Built Environment ICT technicians developed in conjunction with the author a Citrix driven virtual desktop for Revit Server allowing student groups to create and upload a Revit Central model from which local copies are downloaded to students local hardware for creating and editing purposes.

The students had two opportunities during the module for self and peer assessment. This was carried out at the midpoint and end of the module. The student groups were provided with a "live brief" this was a website created by the author containing a set of tasks to be completed by the group on a weekly basis. This allowed the author to direct the learning somewhat remotely. This was done purposefully so as to hand authority for the learning to the student group. The first 6 tasks were designed as a method to get the student group to establish their communication and discourse platform, start building trusting relationships and apply themselves to creating a knowledge community. For the final task, students were given a design and building project on which they had to apply their collaborative skillset. The size of the building project and the timescale were purposefully chosen to intensify the collaboration. Students were clearly informed that the resulting building from the collaboration was not the goal. The recording of the group discourse of their learning journey on the group website was the goal and the assessment reflected this. Flipped learning is a pedagogical approach in which direct instruction moves from the group learning space to the individual

learning space, and the resulting group space is transformed into a dynamic, interactive learning environment where the educator guides students as they apply concepts and engage creatively in the subject matter [17]. Most research on the flipped classroom employs group-based interactive learning activities inside the classroom, citing student-centered learning theories based on the works of Piaget (1964/1967) and Vygotsky (1978) (Bishop and Verleger [18]). The theoretical foundations used for justifying the flipped classroom typically focus on reasons for not using classroom time to deliver lectures. The importance of these student-centered learning theories to the flipped classroom cannot be understated. Without these, the flipped classroom simply does not exist (Bishop and Verleger [18]). The flipped classroom is a suitable approach for a multidisciplinary collaborative learning environment.

4 Findings

4.1 Stage 1: creating a collaborative learning environment

The physical space plays an integral part in collaborative learning, modern technology supported learning environments use a variety of computer mediated communication methods to support collaboration among a community of learners (Jonassen and Rohrer-Murphy [19]). DIT was able to provide a large computer lab with 48 fixed PCs, 2 interconnected projected wall screens, and room around for breakout spaces. Students are expected to engage in first person learning and used the PCs to elicit an instantaneous response to a question. This knowledge is then shared with the group members. The flipped classroom approach allows the students to build their own understanding which is reinforced by the group discourse.

4.2 Stage 2: collaborative group forming

46 postgraduate students from diverse disciplines, architecture, architectural technology, mechanical engineering, electrical engineering, quantity surveying and construction management were divided into collaborative working units. The driver for the formation of the units was to have as far as possible a member from each of the disciplines involved in each unit. The group were briefed by the module leader (the author) and asked to leave their preconceptions behind and open themselves to an environment where as Bruffee [2] states, collaborative learning will give students practice in working together when the stakes are relatively low, so they can work effectively together later when the stakes are high. The author observed the interaction of the group and took notes following the class. The students were ask to the other members of their group and introduce themselves, then find a shared space within the studio to sit and open a dialogue and get to know each other. The student group's first task was to create a communication platform using Google + circles. So each group created an interconnected circle and the class as a whole created a circle.

4.3 Stage 3: the live brief with tasks

The author set flexible boundaries of the constructivist learning approach by way of a "live brief". This brief was a Google website the author created that set out the learning outcomes and the tasks for the collaborative units to tackle. The tasks were set to engage the group in three areas, creating a collaborative platform for discourse, knowledge development of the culture of BIM and a multidisciplinary collaborative BIM building project. Underlying the three areas is the singular task of culture change, re-acculturation, the moving from one community and embracing the language, ethos and culture of another community.

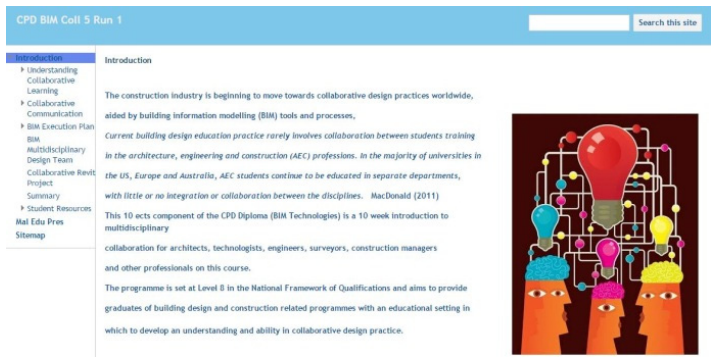

Figure 3: Module "live brief" website.

4.4 Stage 4: discourse and the building of a collaborative team

The second task for the groups was to build a hosting platform to record the discourse and evidence their learning journey using multimedia methods of collaborative writing, illustration, snipped photos of design progress, links to reference material, video tutorials. The groups did this by creating a website individual to each group using Google Sites.

Figure 4: Group website recording their learning journey.

4.5 Stage 5: co-location technology

For a part time module like this is was necessary to provide co-location facilities. This took 2 forms. A collaborative conferencing facility and a Revit Server for Central Models. Students used Google Hangouts to video conference during the week. These online meetings were recorded and placed on their group website as evidence of their learning journey. The recorded video conferences provided the author with a method of observing the group dynamic in action and provided much evidence of the reaccultration developing.

4.6 Stage 6: collaborative building project

The second half of the module had the student groups tackle a design and construct digital building project using their combined BIM knowledge and discipline skillsets and drawing upon the collaborative skills and technologies they had developed so far. The building project was provided by a local authority who had planned to build a Music and Cultural Centre in the Naul, a village in north county Dublin. The project was shelved due to the economic downturn but the LA were able to provide a site, a client requirement (EIR) and a planned accommodation brief. Because of the different build-up of each group the resulting BIM would have different "flavours" some with BIM electrical elements, some with BIM mechanical elements, some with BIM contractor elements, all with BIM architectural elements. All members of the team were given leeway to contribute to all stages of the development of the digital building reflecting Fong's "boundary crossing" and Bruffee's "new community of meaning making".

5 Discussion

It became clear to the author from reading the literature that the education models underpinning the collaborative BIM courses are underdeveloped. These are underdeveloped for several reasons. The main reason being that this is new and there are few 3rd level institutions providing this kind of education. The author recognized a unique opportunity developing in the College of Engineering and Built Environment in DIT. The opportunity to pursue new pedagogic practice by combining collaborative learning theory underpinned by a robust information technology platform and most important an institution willing to respond to a growing demand from industry allowed for the development of this collaborative BIM module. The learning outcome of this constructivist educational model was to break down the barriers that exist between the disciplines in the design and construction industry, get the student participants to open themselves to stepping outside of their community and in a safe unrestricted environment to construct a new community of collaborative professionals using non-foundational teaching and learning theory. Using a set of tasks within the live brief website as a vehicle to transport the student from one community into another to reacculturate as Bruffee proposes. Using the suite of Google apps to record, illustrate and reflect on their discourse has supported the author to develop "A Pedagogy for

Postgraduate BIM Reacculturation". Further research is planned to examine the student's experience of reacculturation.

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