Two Approaches to Implementing BIM in Architectural Curricula

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Abstract. *BIM is an IT-enabled approach that supports enhanced design integrity, efficiency and quality through the distributed access, exchange and maintenance of building data (Haymaker and Suter, 2007; Fischer and Kunz, 2004). More recently, many universities have responded to the adoption of BIM in the profession, by gradually introducing the practice into the curricula (i.e. Cory and Schmelter-Morret, 2012; Ibrahim, 2007; Plume and Mitchell, 2007). Focusing on collaboration – one of the most important aspects of BIM, this paper presents two approaches to implementing BIM in architectural curricula with a focus on collaboration but from two different collaboration scales. Through observation and reflection of these two approaches to teaching BIM, the paper concludes by discussing BIM curriculum design.*
Keywords. *Building Information Modelling (BIM); curriculum design; case studies.*

INTRODUCTION

Traditionally, the collaboration in the Architecture, Engineering and Construction (AEC) industry has been based on the exchange of 2D documents. Although each discipline uses 3D models in practice, the collaboration among disciplines remains largely 2D-based until recently. The large-scale of projects, the increased demand on efficiency, and the proliferation of object-oriented CAD tools have enabled the direct exchange of 3D building data in AEC collaboration. Building Information Modelling (BIM) is envisaged to play a significant role in leading this transformation. Going beyond 3D model, BIM advances object-oriented CAD by defining and applying intelligent relationships between elements in a building model (Lee, Sacks and Eastman, 2006; Ibrahim, Krawczyk and Schipporiet, 2003). BIM models can include both 3D geometric and non-geometric data. The built-in intelligence allows the automated input, exchange and extraction of design and construction documents, as well as other building information, for different disciplines at different stages. This level of intelligence can also reduce errors in design and construction, based on the encoded rules.

Therefore, BIM is considered as an IT-enabled approach that supports enhanced design integrity, efficiency and quality through the distributed access, exchange and maintenance of building data (Haymaker and Suter, 2007; Fischer and Kunz, 2004). Recent commercial CAD tools such as Revit (*http://usa.autodesk.com/revit/*) and ArchiCAD (*http://www.graphisoft.com*) are object-oriented supporting certain BIM capabilities. Various supporting tools have also emerged that can exploit information embedded in a BIM model for different tasks (Khemlani, 2007). Server technologies such as EDMmodelServer (*http://www.epmtech.jotne.com/built-environment.79297.en.html*) on the other hand have been developed as a platform for direct storage, integration and exchange of building data from multiple disciplines based on certain standard data language such as Industry Foundation Classes (IFC), without being limited to specific commercial applications.

More recently, many universities have responded to the adoption of BIM in the profession, by gradually introducing the practice into the curricula (i.e. Cory and Schmelter-Morret, 2012; Ibrahim, 2007; Plume and Mitchell, 2007). There is not a uniformed understanding and practice for implementing BIM education because different academic programs can have varying learning objectives of BIM and very different student cohorts and organisational context. Our research focuses on exploring collaboration – one of the most important aspects of BIM. This paper presents two approaches to implementing BIM in architectural curricula with the focus on collaboration but from two different collaboration scales.

Approach I focuses on intra-disciplinary collaboration within the architecture discipline only, while approach II extends to inter-disciplines towards teaching the more fully integrated BIM practice to a mixed cohort of students. Through observation and reflection of these two approaches to teaching BIM, the paper concludes by discussing BIM curriculum design in terms of the following aspects:

1. The readiness and requirements of the students, the teaching staff and the institute.
2. Principles and strategies that underpin BIM curriculum design.

The paper argues that in BIM education there can be different stages towards teaching the fully integrated BIM practice which is multi-disciplinary at core. Different institutes should critically assess their needs and readiness and understand the implications of those factors, in order to develop a curriculum that is most suitable.

BACKGROUND: BIM ADOPTION AND EDUCATION

BIM adoption

One of the most critically research issues in BIM is its adoption. BIM adoption research explores the industry's readiness for BIM in relation to the aspects of product, process and people, in order to position and facilitate BIM adoption by understanding the current status and expectation across disciplines. It has been identified that there were both technical and non-technical issues that require considerations. The evidence also suggests varying levels of adoption across the industry. There were studies indicating that where even the industry leaders who are early technology adopters in many cases have varying degrees of practical knowledge of BIM and hence at times different understandings and different levels of confidence regarding the future diffusion of BIM technology will co-exist among BIM participants (Gu, Singh, Taylor and London, 2010). Internationally, there are also varying levels of adoption and understanding from country to country, from discipline to discipline and from client to client. Although many researchers and practitioners espouse collaborative working environments in the common practice there are still challenges to be met in many parts of the world, particularly, in relation to a fully integrated collaborative mode of operation by multiple disciplines. These challenges are not only technological but more often cultural and operational.

Therefore to foster and enhance BIM adoption in the AEC industry lie not only in providing technical solutions, in fact it has been identified that implementation and human related issues were the key drawback to wide-scale adoption (Aranda-Mena and Wakefield, 2006). BIM adoption requires changes in organisational culture and calls for new roles and skills of BIM participants (Gu and London, 2010). BIM education can play a very important role in facilitating such changes (Gu, Singh, Taylor and London, 2010). BIM enabling technologies should be integrated into the university curricula, not only as just another set of design modelling and management tools, but as a way to investigate and reflect on the changing nature of the building profession in order to prepare students for these changes.

BIM education

To prepare the BIM-readiness for future AEC professionals and to further the adoption of BIM in the industry, different BIM curricula (i.e. Cory and Schmelter-Morret, 2012; Ibrahim, 2007; Plume and Mitchell, 2007) have been developed and integrated into various AEC-related academic programs. As an emerging educational topic in the AEC domain, BIM education is complex. Firstly, BIM is a multidisciplinary topic. Therefore BIM-related contents are vast and can be sourced at least from the following three areas. Depending on the purposes of the curriculum and the needs of the students and the institutions, the content can vary quite significantly.

- Technology related contents: i.e. tool capabities, building data interoperability, and so on.
- Application related contents: i.e. visualisation, building performance analysis, and other domain specific uses with architecture, engineering or construction focus.
- Collaboration related contents: i.e. communication protocols, teamwork skills, project management, interdisciplinary knowledge, and so on.

Secondly, there is not a standard formula for designing and implementing BIM curricula because each academic program is different with its unique approach to BIM interpretations and practices.

For example, Cory and Schmelter-Morret (2012) implemented a BIM course specifically for the construction discipline. The development of the course was directed by the results of a series of studies that surveyed the professionals about the needs of the industry. Using Revit as the base platform, the course focused on the technical implementation and data flows between the architectural, structural and MEP models in a real-world building project. On the other hand, Plume and Mitchell's approach (2007) focused on the architecture discipline. Students role-played in implementing an interdisciplinary building project using BIM server technologies. Through BIM the course introduced interdisciplinary collaboration to architecture students. The use of the BIM server technology directed the emphasis of the course to building data interoperability. Further, Kensek (2012) surveyed various approaches to BIM education in terms of the broader integration, using the School of Architecture, University of Southern California as a case study. While the study was not exclusive, nevertheless it presented a wide range of objectives and different implementation levels in BIM pedagogy:

- General integration of BIM technologies: The introductory level of BIM courses can be integrated in courses that either focus on technologies (i.e. in an architectural computing course) or focus on design (i.e. in a design studio).
- Advanced BIM-related topics: More advanced and specialised subjects that are enabled by BIM such as performanced-based design, parametric design and modelling, building data interoperability and coordination, and etc. can be embeded and delivered as electives (i.e. in a series of advanced seminars).
- Professional engagement: It was argued that the tertiary education should reach out beyond the student body to the profession, and to be critically informed and evolved through the interactions with the profession. Therefore the third level of BIM education is about professional engagement, which can be facilited through conferences and industry-focused workshops.

IMPLEMENTING BIM IN ARCHITECTURAL CURRICULA

Amongst various technological, cultural and operational foci of BIM, collaboration is one of the most recognised characteristics of BIM, and therefore it became our main focus in developing BIM curricula for the architecture discipline. The rationales of such a focus is also supported by the on-going interest of collaborative work in the field (Kvan, 2000; Achten and Beetz, 2009) and its enabling tools, while in practice failures and losses were observed and often because of inadequate collaboration and communication. The interest by scientists was much driven by the new possibilities that internet provided for distributed work. At architectural schools Virtual Design Studios became immensely popular, because they allowed students from different continents to share ideas (Kvan, 2001) without being physically together. At the same time project websites became mature, and these were quite fastly adopted by the building practice. Project websites support companies very effectively in document management and document sharing (Otter, 2007). Nowadays, with the maturality of the technology, BIM seems to encasulate the above aspects and provides an integrated platform for supporting collaborative work in the AEC industry. This section describes two approaches to implementing BIM in architectural curricula with the focus on collaboration but from two different collaboration scales – intra-disciplinary and inter-disciplinary.

Approach I: intra-disciplinary

Approach I applies BIM in simulating and teaching intra-disciplinary collaboration within the architecture discipline. A case that adopts this approach is the 'Communication in the Built Environments 4' course implemented in the School of Architecture and Built Environment at the University of Newcastle, Australia. Architecture is one of the three disciplines within the School, alongside with Construction Management and Industrial Design. The Australian model of an accredited architectural program consists of two degrees, a three-year Bachelor of Design (Architecture) degree and a two-year Master of Architecture degree. The course is a core subject for the first degree. Among the three disciplines within the School, students are possible to enrol in courses from a different discipline as electives. However, the collaborative teaching and learning is only faciliated at the basic level and more often between the two disciplines of Architecture and Construction Management. They are genenal subjects related to the whole building industry such as design communication (with both traditional tools and digital tools), construction ecology, construction technology and so on. While the concept and the practice of BIM are introduced in various modules across the two disciplines. 'Communication in the Built Environments 4' is the only course that focuses on BIM and faciliates the learning of theoretical understandings and technical skills in implementing BIM collaboration. The course is attended by architectrual students only who has successfully completed a basic digital communication course.

'Communication in the Built Environments 4' was set up initially for the architecture discipline as an advanced digital design and modeling course. With the rapid emergence of new digital design technologies and skill sets, additional digital design courses have been developed to address advanced and more specialised digital design topics such as digital sketching and sculpting, parametric design, and fabrication. These new courses have enabled the re-structure of 'Communication in the Built Environments 4' to remove a part of the digital design and modeling content. As the core digital communication unit, the course was enhanced and integrated with the content of architectural collaboration in 2008. The theory and practice of design collaboration were introduced and exercised through group projects with international partner institutes in the form of a Virtual Design Studio (Gu, Gul, Williams and Nakapan, 2009), powered by commercial 3D virtual world platforms such as Second Life (*http://www.secondlife.com)*. Since 2010, it has been transitioned into the current BIM focus. The shift enables the course to more closely match the needs of the industry regarding collaborative work and BIM. The commercial software adopted, i.e. ArchiCAD Teamwork server (*http://www.graphisoft.com/products/archicad/ac15/teamwork.html*) is architecture-specific and widely known to the local industry. This enables the course to provide students with references to real-world local projects, which contextualises their learning and helps them to better understand the rationale and importance of collaborative work, as many students were found quite resistant against collaborative work especially at the beginning of the course. The current objectives of the course are:

- To introduce the use of BIM in contemporary architectural design practice.
- To introduce the key principles of designing and collaborating in a BIM environment.
- To apply the above knowledge in using ArchiCAD Teamwork server and Web 2.0 technologies for web-based architectural design and collaboration of BIM.

The assessment of the BIM component in the course is a collaborative architectural project. In groups of four to five members, students are required to collaboratively complete a small residential re-design project over seven weeks, using ArchiCAD Teamwork server as the BIM platform supplemented by Web 2.0 technologies for communication and collaboration. One of the main challenges of carrying out the BIM project is the large class size (between 80 to 100 students enrolled each year). With the assistance of the tutors, students are introduced to each other at the beginning and groups are formed voluntarily by the students themselves. In our experiences, students have been attracted to each other and agree to come together as a group for various reasons, i.e. matching skills, existing friendships, previous collaborative experiences and so on, which has enabled the formation of groups with a range of dynamics that can lead to some different and interesting collaborative processes and outcomes. Each group is required to appoint a project manager who coordinates the project collaboration and serves as a regular contact point between the group and the teaching staff. Based on design collaboration theories and practices as introduced in the lectures, each group is then given the flexibility to establish roles and to determine the collaboration processes and protocols that suit its own team dynamics. For example, there are groups being formed based on design roles such as architects, interior designers, landscape designers and so on. Non-design tasks that are related to the BIM model, communication and documentation are then shared by all group members. There are other groups being formed based on task distribution, which can include, i.e. project architects who are in charge of design tasks in general, BIM officers whose key responsibilities are to support and maintain the BIM model hosted on the ArchiCAD Teamwork server, communication officers who lead the design and presentation document production and publish and update the group web site or blog, and so on. Group formation together with the project completion plan form the first formal assessment (10%). Each group is required to present and justify its decisions at an in-class presentation and is critiqued by the teaching staff and other groups. Three weeks prior to the final submission, each group presents the project progress in the studio as the second course assessment (10%). As a group, they are required to critically review the overall progress against the original plan and realistically estimate the completion plan and adjust the plan and collaboration strategies if necessary. As individuals, they are required to critically reflect on their own progress and contributions against the original assigned roles and tasks. The final submission (80%) for each group includes both the group assessment items (50%) and individual assessment items (30%):

- Group assessment items: An original BIM model and various documentations produced from the model; a web-based collaboration portal that captures the development and completion of the BIM project and the group communication during the project.
- Individual assessment items: A self-reflection on the student's own contributions to the BIM project and to the group, and documentations of evidence.

The teaching and learning is structured into two parts. The first three weeks comprise of lectures and technical tutorials. The lectures briefly introduce BIM theories and practices, which also includes a guest lecture by a major local architectural firm that has adopted BIM in supporting its collaborative work. The tutorials on the other hand aim to provide a 'crash course' for developing the students' technical skills in working with ArchiCAD Teamwork server. The remaining four weeks comprise of largely design studios, where the groups are supported and critiqued to develop their projects either on-campus or online.

The score of student overall satisfaction has been consistent (between 4 and 4.2 out of 5), indicating that the students are generally very satisfactory with their experience in the BIM project. Although most students are aware of the increasing importance of BIM in the AEC industry, many are still found resistant against design collaboration and group work at the start of the project. In our case, it is very important to engage students from the start of the project and to provide practical examples to make them understand the rationale and relevance of the project. In this regard, a guest lecture with one of the main local BIM adopters has been successful in contextualising the significance of the issues. In the coming year, we aim to increase the involvement of practitioners to serve as BIM consultants during student project development and during various critique sessions. In group formation, our students are introduced to main conceptual models and core skill sets of design collaboration. They are then given the flexibility to form their own groups based on their understandings of the knowledge. In this case, we believe that such flexibility has motivated the students to be more engaging and to take ownerships of their project, and as a result they are more willing to work with and to overcome difficulties arise during BIM collaboration. In addition, different team dynamics also lead to diverse collaborative processes and outcomes in the whole class. These "alternatives" have enabled the students to see different solutions other than their own and to understand the differences, more importantly to appreciate the complexity and possibility of BIM collaboration. It has been very rewarding to see that during project plan and progress presentations some students can actively participate in discussions on issues beyond their own group. The reflective journals published weekly using Web 2.0 technologies have been another effective tool in the course. Firstly, they are monitoring tools for the teaching staff to gain an overview of the progress of individual students and their group, so that potential issues can be identified and addressed as early as possible. Secondly, they enable the students to self-evaluate their project and collaboration. Finally, they also form the base of each student's individual submission items. In our case, accessing individual students in a group project has been most effective in fostering student engagement and participation.

Approach II: inter-disciplinary

The Faculty for the Built Environment at the Eindhoven University of Technology, the Netherlands is not a typical school of architecture, but has a strong focus on technology. Students can do a Masters in Architecture, Building and Planning (ABP), or in Construction Management and Engineering (CME). The ABP Masters consists of the following graduation tracks: Architecture, building physics and services, building technology and construction, real estate management and development, structural design, urban design and planning. A specialisation on BIM is possible in all graduation tracks, which has enabled the establishment of BIM education across architecture, enginnering and construction. The CME Masters is run by the Faculty of the Built Environment and the Faculty of Industrial Engineering and Innovation Sciences. CME does not differentiate into graduation tracks. For the ABP and CME Master programs, a BIM course is run under the name 'Collaborative Design and Engineering'. The course is attended by students from both Masters programs, hence it consists of a groups of students with a very mixed background and interest. In this section, we examplify the second approach to BIM education through the introduction of 'Collaborative Design and Engineering'. This approach extends the first approach to teaching the more fully integrated BIM practice across disciplines.

The course started in 2006. At the start of the course the main aim was to teach and to practice collaborative design using file sharing and communications tools. Collaborative design was considered more than just cooperating on the same task. We were convinced that a building project can only be successful if all disciplines truly understand and respect each other. The challenge was to investigate how the internet technologies can support this state of mind and how it can manage the process.

In parallel to the teaching the Collaborative Design and Engineering (CDE) course, the Design Systems group of the Eindhoven University of Technology has been involved in BIM research and development since the mid 1990s. At that time this research was named product modelling and process modelling and it took many years before standards and tools became mature. Since approximately 2008 a wealth of software has become available that supports the BIM process. It seemed obvious to integrate BIM knowledge and technologies into the CDE course. Today the course has a strong focus on BIM as a supporting technique for successful collaboration in a building project. The learning objectives are:

- Architectural design and engineering: To gain insight in what architectural design and engineering processes are and what paradigmata exist for these processes.
- Multi-disciplinary design: To gain insight in the specific aspects of multi-disciplinary design. To know what social processes are important in team-design.
- Designing design processes: To gain insight in designing design processes, facilitating design processes. To learn to work in autonomous design teams.
- Building Information Modelling (BIM): To gain insight in the application of Building Information Modelling methods and techniques to support multi-disciplinary design.
- Computer support: To get acquainted with and to evaluate means for computer support for multi-disciplinary design. To be able to apply these means for one's own design processes and to experience the possibilities and limitations of these means.
- Systems Engineering: To gain insight in Systems Engineering theories and putting these theories into practice in a concrete project.

In this paper we focus on the implementation of BIM in architectural curricula. Hence we only highlight here the BIM aspects and leave out the other learning objectives. The course assessment consists of a design assignment, namely a new shopping mall annex offices in the Eindhoven city centre. For the assignment the group of enrolled students (approx. 40) are split into two consortia that will compete with each other on the best project plan. A consortium consists of four companies, with three to five students each: Architects, Engineers, Urban Designers, Project Developers. Project Developers have two responsibilities: Real estate management and project management. At the start of the course a CEO is appointed for each company. The remaining students can apply for a job in a company through a job application letter with a short CV. The job application letter is sent to the teacher and the students need to indicate a first and second choice. Students are distributed over the companies according to their first choice as much as possible. The course lasts 10 weeks and is rewarded with 7.5 ECTS, which means that students spend 2.5 days per week on this course. In the first three weeks lectures are given on specific Collaborative Design and Engineering topics. In parallel workshops are organised for practicing BIM methods and techniques. After three weeks each consortium presents its project management which includes: Information plan, communication plan, time plan, organisation breakdown structures, work breakdown structure, functional breakdown structure, functional and general requirements, system breakdown structure, function-system matrix, process model and exchange requirements. From the fourth week on, the consortia work on the design assignment. In this period the teachers only give guidance on the process and help to solve technical issues. After eight weeks the consortia present their final plan. The target audience is the mayor of the city. Two weeks later the following reports are submitted:

- Individual: Literature study, reflection report.
- Company: Product report, process report.
- Consortium: Project management plan, project design.

In the CDE course BIM lectures give an overview of the BIM history and the state-of-the-art in today research and development. In the workshops we practice the following BIM methods: Systems Engineering using COINS Navigator, Building Process Model Notation (BPMN) using Microsoft-Visio, and IFC model sharing using the BIM server. Systems Engineering is already common practice in civil engineering, but now it has also gained attention from the architectural field. COINS-navigator (*http://www.coinsweb.nl/wiki/index.php/COINS_Navigator)* is a free-ware tool that supports specification of functions, requirements, systems and performances in a systematic way. It helps students to elicit and specify the objectives of their design. BPMN is advocated by the BuildingSmart community as the preferred method for creating process models and exchange requirements. The process model helps the students to explicitly describe who are exchanging information, in which order and in what format. The BIMserver is an open-source server (*http://www.bimserver.org*) that supports management and sharing of IFC models and CityGML models. Students configure the platform and it leads them to collaborate through sharing models instead of transferring document files.

In general students are quite positive about the course. For most students it is the first time they truly collaborate on a common assignment. Students with a background in design and engineering are used to work on their own project. In this course the design process is a true collaborative effort and with the right mind set it is more than just an aggregation of work parts. For students with management background it is the introduction into the complexity of designing and engineering a building. A delicate issue is the balance between the rewarding for the process and the product. Unlike typical design projects, in this course the process is equally important. Focussing only on the process would result in a very theoretical course that misses the pressure to work on a good design and hence lack the collaboration experience. Because the total course duration is relatively short but yet very intense, the number of design cycles is limited. The process models including the exchange requirements are created one design cycle ahead. Moreover, since students spend much time together, the need for digital model sharing and telecommunication is lower than in real practice.

Students are very well aware of the BIM urgency, thus they are very interested in the topic. Experience with BIM tools is very diverse, but students manage quite well to divide the learning work load within the companies. Technically current BIM tools show many shortcomings and failures. A major learning objective of this course is to find work-around for these problems. We train the student to document and test the collaboration process up front in order to prevent trouble and frustration during the design and engineering process. Although challenging and frustrating sometimes, students appreciate that they can work and experiment with state-of-the-art technologies.

Next year we will add an exam to the Collaborative Design and Engineering course. In recent years we concentrated on the organisation of the course. Today many scientific BIM publications are available that are a good basis for course materials. Additional to the technical and collaboration skills that are now examined through the reports we will also test their knowledge on BIM theory. Another wish is to involve practitioners from the building industry as consultants during the design and engineering process and for the final evaluation.

DISCUSSION AND CONCLUSION

This paper has presented two cases of implementing BIM in architectural curricula. The courses focus on collaboration, one of the main characteristics of BIM. These two courses adopt two different approaches as discussed above and have very different scales in collaboration. Approach I applies BIM for intra-disciplinary collaboration within the architecture discipline only. Approach II explores the full benefits of BIM through a more integrated collaboration across multiple disciplines for a mixed cohort of students. The different set-ups of the courses closely reflect on their differences in terms of the backgrounds of the enrolled students, the needs of the programs, the context of the institutes and the resources available. The evidence from the industry shows that although the potentials of the fully integrated BIM across all AEC disciplines have been widely recognised, however there are still varying levels of adoption across the industry. This is because for each practice, the transition to the fully integrated BIM is highly individualised and will need to match its readiness and be tailored for its specific needs. Similarly in BIM education, there can be different stages towards teaching the fully integrated BIM practice that has its core in multi-disciplinary collaboration. As shown in the two case studies above, different institutes should critically assess their needs and readiness and understand the implications of these factors, in order to develop a curriculum that is most suitable.

To conclude the paper, the following discusses the readiness and requirements of the students, the teaching staff and the institute. We then highlight some corresponding principles and strategies for BIM curriculum design, especially for facilitating and assessing collaboration. There is not a standard formula for designing and implementing BIM curricula, it is important to acknowledge the different contexts and needs of each academic program when introducing and facilitating BIM in their students' learning.

In terms of the readiness of the students, there can be varying levels of perceptions on and skills of new technologies as well as collaboration. In interdisciplinary scenarios, the issue can be even more complex. In our second case, students with a background in design and engineering are more used to working on their own. For BIM the design process is a true collaborative effort and the right mind set for collaboration has never been more important. For students with management background the technical and cross-disciplinary knowledge and practice such as the complexity of designing and engineering a building can be a challenging learning experience. Therefore it is very important to engage students from the start of the project and to motivate their learning by clearly communicating and contextualising the rationale and relevance of the project to their professions through practical examples and the involvement of BIM adopters from the industry.

A balance of both theoretical, practical and technical course contents, an engaging project brief with industrial relevance, a well-formed collaborative team can each play a part in enriching the student's BIM experience. Once the students take ownerships of the projects, they are more willing to work with and to overcome difficulties arise during BIM collaboration. Besides these factors, it is arguable that the most important and motivating factor for many students is in fact a suitable and fair assessment design. Unlike typical design projects, for BIM the process is equally important. Therefore, a delicate issue is the balance between assessing and rewarding the process and assessing and rewarding the final product. Depending on the context, it is also important to assess both the group performance and the individual performance. In our first case, accessing individual students in a group project has been most effective in fostering student engagement and participation.

To facilitate BIM collaboration is also very challenging for the teaching staff. BIM is a multidisciplinary topic and BIM-related contents are vast and can include but not limited to technology related contents, application related contents, and collaboration related contents. It is important to allow the students to understand this level of complexity but without overwhelming the students. To achieve this, it often requires the careful set-up of the course as well as the project and the collaborative team, so that different disciplinary knowledge can be shared and executed by different team members. It is also required for the academics to find the balance between being a facilitator/collaborator and a monitor/assessor and act accordingly during the course to support the students more effectively.

While moving towards teaching a more integrated BIM collaboration across multiple disciplines for a mixed cohort of students, the complexity of the course increases significantly. To facilitate such courses often requires effective collaboration among staff members across disciplines and across schools/departments.

Finally for the institute, to effectively integrate BIM curricula requires a strong commitment to recognising, resourcing and realising collaboration and communication as an important graduate attribute in the program design. BIM enabling technologies should be integrated into the university curricula, not only as just another set of design modelling and management tools, but as a way to investigate and reflect on the changing nature of the architecture and building profession in order to prepare students for these changes. The implementation can take different stages to suit the needs of the institute and to better prepare for its transition, however it will require strong efforts in innovating the course, program and degree structures to enable collaboration and encourage interaction among disciplines within the institute.

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