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CONSTRUCTING BUILDINGS, BUILDING KNOWLEDGE

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INTRODUCTION

My journey began five years ago as a facilitator in the Bachelor of Architectural Studies (BAS) program at Otago Polytechnic in the Otago region of New Zealand. This was driven by a passion for digital technologies and Building Information Modelling (BIM). Transitioning from my role as a senior architectural technician in industry to academia presented a challenge, as it required me to transform my practice-based methodologies into methods and tools for experiential learning. This transformation was centred on my belief that architectural education should develop key practical skills and knowledge for learners that employers in industry can leverage and grow.

DEFINING BUILDING INFORMATION MODELLING (BIM)

The digital evolution has infiltrated many parts of modern life, including the realm of education. In architectural education, the shift towards digitalisation began with the development of AutoCAD in 1982 and is now encapsulated in the integration into the discipline of Building Information Modelling (BIM), a tool that has transformed how architects and technologists design, collaborate, visualise and think about buildings. BIM has been taken up by the Architectural, Engineering and Civil fields as a term to differentiate between traditional 2D computer-aided design (CAD) software applications and newer CAD applications. These newer applications incorporate graphical, parametric and relational database technologies designed to create integrated, data-rich 3D models of buildings, systems and infrastructure.

BIM has significantly changed architectural practice in recent years, allowing designers to digitally simulate and analyse proposed building designs. Subsequently, it has had an impact on architectural education, specifically within technical courses such as Documentation Studio, which I facilitate. Michael Ambrose captures this evolving state: "Building Information Modelling (BIM) has the potential to radically transform the way in which architectural education engages issues of design and representation and creates opportunities to question the roles and rules of the traditional architectural conventions of visual communication."[1] At Otago Polytechnic, we use BIM not just as software, but as a pedagogical tool to bridge the gap between theory and practical application within our BAS program.

BIM is often misunderstood as software for architects and engineers. In reality, BIM represents a shift in design and construction communication, offering a single coordinated digital representation of the physical and functional characteristics of place and objects. BIM also offers a collaborative process for communication and information exchange among stakeholders typically involved in a building project. In an educational context, BIM can serve as a tool for experiential learning, allowing learners to engage directly with the complexities and variety of architectural projects in a simulated environment at a level appropriate to them.

DEFINING DOCUMENTATION STUDIO

Architectural design/studio practice develops concepts for the buildings that surround us, but without detailed construction drawings a building itself cannot be realised. This is where the BAS program's Documentation Studio comes in to provide the framework, tools and knowledge that learners require to communicate key technical aspects required for physical building construction. Documentation drawings transform a conceptual building design into tangible reality, ensuring that the original design intent is conveyed with clarity.

An educational framework designed to deliver technical knowledge, while developing a holistic understanding of architectural structures and systems, is essential. Reviewing how this relates to the industry as a professional body requires a clear understanding of the intersection between these worlds. Learners grapple with the idea of architecture as a complex system that gathers layers as the original design idea becomes a realised physical outcome. In order to negotiate this process with them, we approach the learning environment as a simulated office 'scenario.' In this sense, learning activities mimic the process of 'doing' architecture and are designed to teach some of the soft skills that industry is seeking in graduates, as well as the more technical elements that are introduced progressively as projects unfold. Documentation Studio is the vehicle for this learning to occur – this is established through the introduction and use of the tools of the trade, such as CAD and BIM. In this setting, skills and knowledge expectations are not presumed, but rather built from the ground up through a collaborative process.

PHASE ONE: THE LEARNING ENVIRONMENT AS A SIMULATED OFFICE 'SCENARIO'

Developing a 'cradle-to-construction' culture (the process of taking a concept sketch design to detailed construction tender documents) is essential for architectural business, and every design office culture is unique due to the range of personalities, communication styles, skills and knowledge of staff. This is also true for learning environments, and Documentation Studio is no exception. It provides the raw ingredients for the educational framework.

Provision of a safe learning environment to support the 'doing' process is key to the simulation scenario. Any question, no matter how simple or obvious, must be safe to ask within a formal or informal setting. Learners must develop confidence in their environment as a safe place and also in their peers' ability to support them in the context of the aggregation of knowledge available among them at the time.

As BIM can be a complex tool, the approach begins with a simplified BIM model, like a simple shelter, with very simple construction. In this way, the complexity of bespoke design does not inhibit fundamental learning. For learners, the process involves testing and mastering the nuanced digital tools available to create and refine 3D BIM objects; researching manufacturers' information, codes and standards; and coordinating these elements with structural BIM data.

Success is anticipated to vary within this process, and learners are urged to share research methodologies, product information, codes/standards and processes. They are required to integrate these 'layers' into a comprehensive BIM solution, not just in theory but as an assessable digital 3D/2D constructable outcome. Learners actively construct their understanding and knowledge through engagement with digital modelling tasks. This hands-on interaction with their own architectural project allows them to process and synthesise information and apply concepts.

Active discussion of experimentation, failures and technical issues among peers and facilitators while in the midst of the 'doing' is key to establishing the learning environment as a simulated office 'scenario.' The facilitator's role in this is to promote information sharing among peers, identify gaps and common issues among learners and to validate outcomes using industry best-practice examples where possible.

This approach intersects and overlaps professional practice, where diversity of skill and experience is shared to deliver the whole. For example, junior members of an architectural practice might offer advanced representation techniques for graphic presentations, while experienced practitioners share proven technical solutions such as exterior flashing detailing for bespoke roofing and wall-cladding solutions.

PHASE TWO: 'BUILDING' BUILDING COMPLEXITY

As stated above, the starting point needs to be (technically) simple so that fundamental understanding of and familiarity with the BIM tools can be developed, uninhibited by the complexities of design and construction.

Once these fundamentals are established as the first step in the staircased learning process, we can leverage increased learner confidence in BIM tools to develop additional scale, complexity and detail built on the knowledge developed during the creation of the simple shelter. In practice, this learning outcome materialises as a much larger, multi-storied building project which is used within the educational framework as a case study, activity/experimentation model and summative assessment model.

Learners start with a blank slate or site and, just like a 'physical' construction team, they construct/assemble/digitally model 3D building elements from foundations to roof, sequenced (when possible) in alignment with typical onsite construction phases.

This process unfolds over the course of a 16-week semester and, upon completion, results in a highly detailed 3D description of architectural form and structure (see Figure 1). The entire process is broken down into chunks of sequenced building categories and elements. Learners create construction elements such as concrete foundations, precast walls, steel reinforcing and structural wall connections (see Figure 2).

The cyclical approach involving doing and reflecting that was discussed above in relation to the 'shelter' phase is repeated through this process. The added layers of information incorporated during this phase prompt learners to examine and evaluate relationships between the digital versions of various construction elements. The types of questioning that follow suggest a deeper level of understanding of the component relationships newly created within the building model. Examples of such questions are: How far should the reinforcing steel be from the exterior surface of the concrete? What materials and methods are used to join walls and foundations? What might determine the quantity and type of reinforcing used?

Approaching the 'building up' (staircasing) of the model sequentially means that learners are continually advancing their knowledge and developing already established collaboration and communication pathways. Learners have the advantage of these skills being subconsciously embedded within the process of 'doing.' As each cycle is repeated, efficiency, analysis and knowledge relating to the 'simulated office' is honed.

PHASE THREE: DISCOVERING BUILDING SYSTEMS

Continuing the cyclical process that learners have developed through phases one and two, we can now introduce the next layer of complexity: building services and systems. The advantage of introducing this subject last is that, by this stage, most learners have developed a robust foundational knowledge of the structural and architectural elements that make up a building.

Building services can significantly influence architectural and structural planning. These services include networks for water, electricity, air conditioning, fire safety and communications, collectively known as MEP (mechanical, electrical and plumbing). All of these building services and their associated infrastructure occupy significant space within a building. Considered integration, design and coordination of these systems can prevent major construction issues occurring during real-world construction,[2] saving time and money.

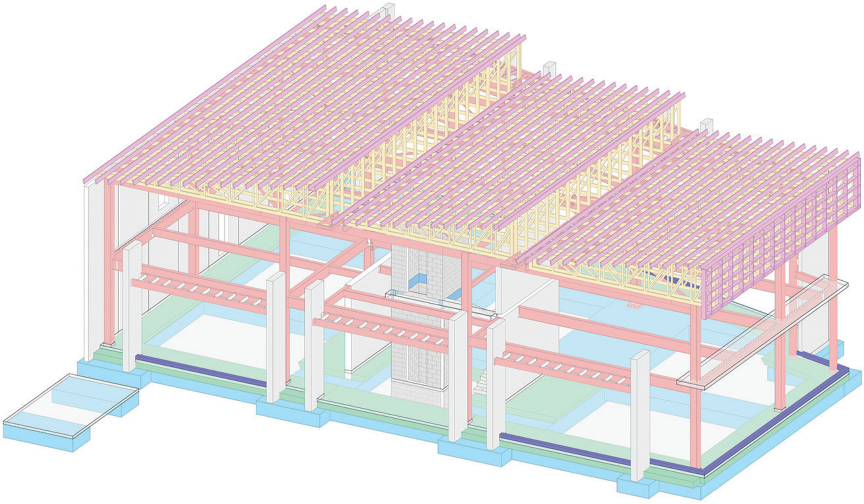

Figure 1. Sample of a BIM structural model used to support learning about architectural form and structure.

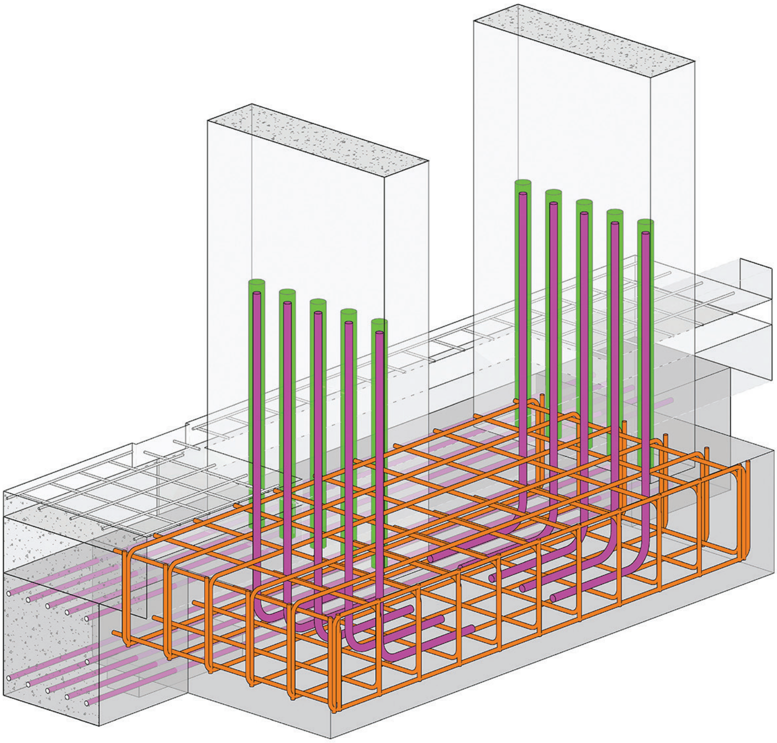

Figure 2. Detail of a BIM model describing precast concrete connections and reinforcing.

There are two critical learning objectives that are revealed through this process in the class scenario that are regularly encountered in practice. They are the identification of the actual space required for the infrastructure and distribution of services, and resolving coordination issues – such as two service elements potentially occupying the same space (for example, a ventilation supply diffuser and a lighting fixture, or ductwork intersecting a structural beam).

One of the primary uses of BIM is to identify and resolve potential clashes between structural elements and services systems before actual construction begins. Through an automated digital process known as clash detection, BIM software verifies space clearances around objects that may or may not intersect or interfere with each other within the model. This information is automatically extracted and summarised so that each clash can be addressed and resolved. Contemporary BIM combines this technology with communications and resolution tracing among consulting disciplines.

Utilising a digital library of components, learners are required to assemble and place various horizontal and vertical infrastructure elements and fixtures. The building up of the system means that learners receive a deeper understanding of various components and their composition. Also, most critically, they develop an understanding that services should be integrated into a building, as opposed to applied post-design. What also occurs in this 'discovery and problem-solving phase' is an appreciation of design as a collaborative process, activating discussions around communication issues in a multi-disciplinary environment. These discussions often revolve around complex questions including: Which element or building system takes precedence and why? How do respective engineers communicate and resolve this? What are the contemporary BIM tools used in industry to resolve these issues? This process, and the discussions that flow from it, highlight the importance of coordination and collaboration – which learners will encounter in practice – as consultants and designers working on a single project are often geographically separated.

CONCLUSION

Documentation Studio within the Bachelor of Architectural Studies program at Otago Polytechnic utilises Building Information Modelling (BIM) as a pedagogical tool to bridge the gap between theoretical architectural education and practical application. By creating a simulated office environment where learners sequentially build upon their knowledge and skills, the program aims to develop both the technical expertise and the collaborative, problem-solving abilities that are essential for success in the architectural profession.

This approach involves starting learners with a simple building model designed to help them master the fundamentals of BIM software and processes. Complexity is then progressively layered, by modelling a larger, multi-story building, and then by incorporating building services and systems. This staircased learning approach allows learners to develop a holistic understanding of how the different architectural elements and disciplines must be coordinated.

Through this experiential process, learners gain practical experience of converting conceptual designs into comprehensive construction documents. Equally important, they learn to navigate the collaborative nature of modern architectural practice, identifying conflicts, communicating with peers, resolving issues and developing skills that are critical for success in the industry.

Blair Isbister is a licensed building practitioner and senior lecturer at Otago Polytechnic. Specialising in Building Information Modelling and healthcare design, he is passionate about software and building systems technology. With over 15 years in the design and construction industry, he enjoys bringing practical insights to his practice and fostering a dynamic learning environment for aspiring professionals in architecture and construction.

1 Michael A Ambrose, "Plan is Dead: To BIM, or not to BIM, That is the Question," paper presented at Computing in Architecture / Re-Thinking the Discourse: The Second International Conference of the Arab Society for Computer Aided Architectural Design (ASCAAD 2006), Sharjah, UAE, April 2006, 182.

2 Wael Abdelhameed and Weldy Saputra, "Integration of Building Service Systems in Architectural Design," *Journal of Information Technology in Construction,* 25 (2020), 109-122, doi:10.36680/j.itcon.2020.007.