# Integrating Collaborative Technologies within a BIM Course for Ireland's AEC Sector: Overview and Proposed Research Directions

Shannon Chance
TU Dublin, Ireland, shannon.chance@tudublin.ie

**Abstract**

This paper examines the integration of collaborative Building Information Modelling (BIM) technologies within the Bachelor of Science (Honours) in BIM (Digital Construction) course at Technological University Dublin, a course designed to upskill professionals in Ireland's Architecture, Engineering, and Construction (AEC) sector. Recognising the inherently interdisciplinary nature of modern construction and the collaborative workflows enabled by BIM, the course strategically incorporates technologies such as Revit, ArchiCAD, and MagiCAD for discipline-specific modelling, as well as Navisworks and BIM360 for multidisciplinary coordination and clash detection. This practice paper details how these technologies facilitate active and immersive learning, mirroring real-world industry practices while fostering reflective practice and multi-disciplinary teamwork. The paper highlights the crucial importance of developing collaborative skills for the digital transformation of the Irish AEC sector. Building on the BIM course overview and the role of collaborative technologies, this paper concludes by proposing future research to enhance the understanding and practice of BIM education within engineering education research, which may inform the development of similar educational offerings.

***Keywords***: BIM Technologies, Engineering Education, Collaboration, Multidisciplinary, Digital Construction

## 1 Introduction

The surveying and construction innovation programs at Technological University Dublin (TU Dublin) are designed to support the digital transformation of Ireland's Architecture, Engineering, and Construction (AEC) sector by equipping students with critical skills in Building Information Modelling (BIM) and related collaborative technologies. The program is designed for mature students, employed or seeking employment in the AEC sector, who complete their studies within a 12-month timeframe. This practice paper describes our integration of advanced active learning methodologies and collaborative tools, such as BIM360, Navisworks, and Revit, to foster lifelong learning and innovation within the AEC sector (Bonde, 2023). Central to this approach is the incorporation of project- and problem-based pedagogies, which provide students with hands-on experience and support in solving real-world challenges (Chance & McAuley, 2023a). Research-driven learning further enhances this process by ensuring that students not only master technical tools but also engage critically with emerging trends and innovations within the industry (Chance & McAuley, 2023b).

Our course emphasises cloud-based collaboration, interdisciplinary teamwork, and the development of reflexive thinking and problem-solving skills, which are essential in a sector that increasingly relies on integrated digital workflows (Chance, 2024). Our blended learning model combines in-person instruction,

synchronous online sessions, and work-based learning, allowing students to engage in flexible, dynamic, and immersive educational experiences. Through this model, students also develop essential leadership, strategic thinking, and communication skills critical for managing the complexities of modern construction projects (Black & Gregersen, 2013; Fullan, 2007).

The outcomes of this pedagogical approach are multifaceted: students gain technical proficiency in digital construction platforms and develop improved competencies in teamwork and leadership, which are critical for driving innovation in a rapidly evolving industry. Moreover, the continuous iteration of pedagogy and technology has been key to refining our approach, enabling us to respond to industry shifts. The paper suggests directions for additional research to support the iterative improvement of the course and similar courses. We hope readers will gain insight into how such strategies can be adapted across various educational contexts to prepare students for leadership roles in a digitally transformed AEC sector, both within and beyond Ireland.

## 2 Overview of the course

This bachelor's level BIM course employs active and immersive learning approaches across all modules. The hands-on activities include projects tied to each student's employment in the sector, such as case studies, action research projects, modelling and clash detection, and project planning. The course also requires reflective journaling and peer-to-peer learning, fostering reflexivity, critical thinking, and collaboration skills. The modules are listed in Figure 1; every student completes one module from each row, for a total of 60 ECST (i.e., on the European Credit Transfer System).

| credits | module name | | | | contact |
|---|---|---|---|---|---|
| 5 | Digital Construction Principles & Standards | | | | 24 |
| 10 | BIM Architectural Modelling & Review | BIM Civil & Structural Modelling & Review | BIM MEP Modelling & Review | BIM Construction Model Exploitation & Review | 48 |
| 10 | BIM Federation & Validation | | | | 48 |
| 15 | Work-Based Learning | | Special Collaborative Project | | 16 |
| 5 | Research Methods | | | | 24 |
| 15 | Dissertation with Agile Project Management | | | | 30 |

Figure 1: Module provided in this BIM course (Source: Chance, 2024)

The university is actively involved in research and education, supporting the digital transformation of Ireland's AEC sector, with a particular focus on BIM and BIM Management. These digital methodologies are crucial for fostering efficiency, minimizing errors, and driving innovation within the industry. Several key aspects of TU Dublin's work contribute to this digital transformation.

**BIM Education and Upskilling:** TU Dublin offers comprehensive BIM education programs, including this and research-intensive honours BSc in BIM (Digital Construction), launched in 2020. It complements an MSc offering in applied Building Information Modeling and Management (aBIMM), offered since 2015. These programs aim to upskill working professionals and inject new BIM knowledge and skills into the Irish construction sector. The curricula integrate active learning methods, such as group work and project assignments, to prepare students for the collaborative nature of modern AEC.

**Student Research as a Driver of Innovation:** A significant component of the BIM programs involves student research via dissertations and capstone projects. The research addresses real-world challenges in the Irish AEC context and encourages students to propose and evaluate solutions relevant to their organisations. The themes explored by past students have included implementing BIM, improving industry practices (especially

in SMEs), leveraging BIM for lean and efficient practices, and utilising BIM in areas like facilities management, heritage conservation (HBIM), and energy retrofits (Chance & McAuley, 2023a).

**Scaffolded Approach to Research Skills:** TU Dublin employs a stepped and scaffolded approach to support students in developing research skills (Chance & McAuley, 2023a). This equips graduates with the ability to critically analyse information, propose solutions, and contribute to the knowledge base of the Irish AEC sector. The BSc research typically involves synthesising existing literature on topics relevant to Ireland, often leading to the development of new models, workflows, or frameworks.

**Alignment with Industry Needs:** The BIM courses are designed to be highly applied and relevant to the needs of Irish industrial and governmental employers. The research undertaken by students often addresses specific challenges encountered within their workplaces, fostering a direct link between academic learning and practical application. The format of student theses often mirrors conference papers for industry-relevant events like the bi-annual Construction Information Technology Alliance (CitA) BIM Gathering.

**Dissemination of Knowledge:** Student and faculty research outputs, including conference papers, industry reports, and thesis documents, are often made available through the university's research repository, ARROW@TU Dublin. This facilitates the sharing of knowledge and best practices within the Irish AEC community and beyond. MSc capstone papers have been downloaded thousands of times internationally, indicating the broader relevance of this research (Chance & McAuley, 2023a).

**Focus on National Context:** There is a strong emphasis on applying BIM within the specific context of the Irish construction sector, with many student dissertations focusing on national-level issues and adapting international research to the Irish environment. This targeted approach aims to address the unique challenges and opportunities within Ireland's AEC landscape.

Overall, TU Dublin, through its BIM education programs and the research conducted by its students and faculty, plays a vital role in fostering the adoption and effective use of collaborative digital technologies, such as BIM, within the Irish AEC sector. This work contributes to the sector's digital transformation by upskilling professionals, generating relevant research, and disseminating knowledge to improve industry practices and drive innovation.

# 3 Overview of collaborative technologies

The BIM BSc course utilises several technologies to facilitate and promote collaboration among students and with industry practices. BIM software, such as Revit, ArchiCAD, and MagiCAD, is central, enabling students from different disciplines (Architecture; Civil & Structural, and Mechanical, Electrical, and Plumbing (MEP)) to create and share digital models of buildings. Collaboration is further enhanced using Navisworks (geared toward our Construction Management students, with engagement from students of all disciplines represented in the course). Navisworks allows students to federate these discipline-specific models, run clash detections in multidisciplinary teams, and analyse the integrated project information. The course also employs BIM360 as a platform for collaboration, supporting teamwork in the "Federation and Validation" module. The cloud-based nature of BIM facilitates blended learning, using both synchronous and asynchronous approaches for collaborative learning activities. Beyond specific BIM tools, students develop web-based e-portfolios (using Adobe Portfolio or Brightspace ePortfolio) with secure OneDrive file storage. These tools help students reflect on, cultivate, and showcase their learning. Finally (up until 2024), access to LinkedIn Learning (LIL) provided students with resources for self-directed exploration of various technologies relevant to collaborative BIM workflows and project management. These technologies collectively support the course's active and immersive learning approach, fostering hands-on experience and preparing students for the collaborative environment of the AEC sector.

Learning to collaborate is essential in the course and in the broader AEC sector. For one, the AEC sector is inherently interdisciplinary. Modern construction projects involve professionals from diverse fields, such as

architecture, structural engineering, MEP engineering, and construction management. BIM, as a digital project management tool, necessitates that these different disciplines work together seamlessly. The course mirrors this by having students break into discipline-specific streams for modelling but then come together in multidisciplinary teams in modules like "Federation and Validation" to integrate their models, run clash detections, and resolve errors. This experience in collaboration is vital for their future professional practice.

Secondly, BIM workflows are inherently collaborative. The technologies used in the course (such as Revit, ArchiCAD, MagiCAD for discipline-specific modelling and Navisworks and BIM360 for federating models and managing project information), are designed to facilitate shared access and collaborative work on project data. Understanding how to use these tools effectively in a collaborative setting is a core learning outcome, as it reflects how BIM is implemented in industry.

Thirdly, collaboration fosters better problem-solving and innovation. When individuals from diverse backgrounds and with varying expertise collaborate, they bring a range of perspectives to the table, leading to more comprehensive problem analysis and innovative solutions. The course design, with its emphasis on group work, field- or work-based activities, and project assignments, actively promotes this collaborative problem-solving process.

Moreover, research in BIM emphasises collaboration. By engaging in research projects related to BIM, students learn how to collaborate effectively across sub-disciplines. This is a key aim of the BSc course, which encourages students to address real-world challenges and implement proposed solutions within their organisations, via interaction with colleagues from different departments or specialisations.

Professional bodies and industry expectations also emphasise collaboration. Our course curriculum and learning outcomes are aligned with the frameworks of professional bodies, such as Engineers Ireland, the Society of Chartered Surveyors Ireland/Royal Institution of Chartered Surveyors, and the Chartered Institute of Building, all of which recognize the importance of collaboration in the modern AEC sector. The course explicitly aims to foster students as effective BIM collaborators, prepared to meet industry needs.

Challenges in PBL, as highlighted in the literature, often revolve around teamwork and collaboration. Recognising and addressing these challenges in a supportive academic environment prepares students for similar issues they might encounter professionally. The course's integration of reflective journaling and peer-to-peer learning allows students to process their collaborative experiences and learn from one another.

All in all, the complexity of modern AEC projects combined with the collaborative nature of BIM methodologies makes the ability to work effectively in teams an indispensable skill. This BIM course intentionally integrates various technologies and pedagogical approaches to cultivate these collaborative skills, to prepare graduates to contribute meaningfully to the digital transformation of the Irish AEC sector.

# 4 Evidence of Impact and Results

Regarding our students' research success and impact, three BSc dissertations from the course have achieved significant recognition, contributing to areas like energy-efficient design (Grego et al., 2023), structural design optimization (McLoughlin & McAuley, 2022), and enhancement of estate management within the healthcare sector (Martin et al., 2021). These specific examples provide strong evidence of the course's practical impact (Chance, 2024). Our students' research often focuses on national-level issues in the Irish AEC context, exploring new processes or tools, and addressing real-world challenges. The MSc capstone papers have been downloaded thousands of times internationally, indicating the broader relevance and successful dissemination of knowledge generated through TU Dublin's BIM programs.

**Graduate Attribute Development:** The curriculum aligns with TU Dublin's Graduate Attributes, fostering enterprising skills such as innovation, leadership, collaboration, and entrepreneurship. The course emphasizes global responsibility, ethical conduct, effective communication, critical thinking, problem-

solving, reflective practice, digital literacy, teamwork, emotional intelligence, strategic thinking, and resilience.

**Demonstrated Learning Outcomes:** Core learning outcomes include students' ability to create discipline-specific BIM models, utilize appropriate BIM standards, coordinate BIM models across disciplines, and exploit BIM models for various tasks (e.g., cost, energy, design).

# 5 Evaluation Methods and Quality Assurance

Our rigorous assessment involves formal procedures that include continual data collection, course-refinement activities, and twice-annual assessments by external examiners. The course was validated by Ireland's Higher Education Authority (HEA) in 2018 and is subject to continuous review. We use structured rubrics to assess student performance, thereby providing formative and summative feedback and helping ensure reliable reviews by multiple staff members. The Module Boards that we conduct each semester involve review by two external examiners (one from industry, one from another academic institution), to ensure validity, coverage, rigor, and fairness of grades. This follows meetings of the Program Review Committee, comprised of student representatives and teaching staff. The Committee meets each semester to consider student feedback, address concerns, and identify areas for improvement. The External Examiners have provided feedback such as: "The Project-based approach, both at individual and group level, is very practical and reflects industry situations" and the "Programme content is extensive and all modules are relevant to Industry needs [both present and future]". The examiners have also emphasized the program team's responsiveness and continuous improvement by noting positive developments within the Work-Based Learning (WBL) module following feedback examiners previously provided. We use an ongoing process of reflection and critique of current practices to enhance course design and delivery, as discussed by Chance (2024).

# 6 Proposal for future study

We have ideas for engineering education research projects that could expand our understanding of the BIM course. A study evaluating the effectiveness of the BIM/Digital Construction course in nurturing leaders who have made significant contributions to the Irish AEC sector could provide valuable insights. Such a study could involve surveying and/or interviewing graduates, in a research design underpinned by a leadership model such as Fullan's (2007) or Black and Gregerson's (2013). We aim to assess how well the BSc course equips graduates to contribute as leaders in the Irish AEC sector, describe graduates' career trajectories, and identify leadership roles they have assumed following their BIM education.

A second idea worthy of study involves further exploring the active learning pedagogies used in this course, as outlined in a study underpinned by the well-cited journal article by Chen et al. (2021). The research question for such a study could be:

> ***How do the design and implementation of the TU Dublin BSc (Honours) in BIM (Digital Construction) course align with the levels of PBL implementation identified by Chen et al. (2021), and what challenges encountered in the course resonate with the individual, institutional, and cultural level challenges reported in their review?***

By answering this research question, an applied research project could provide valuable insights into applying PBL in a specific digital construction context, using a well-established framework from the engineering education literature. This would contribute to understanding the implementation of PBL and the pedagogical approaches in BIM education. Here is how we could approach it:

**Alignment with PBL Implementation Levels:** We could analyse the course based on the four levels of PBL implementation identified by Chen et al. (2021):

- **Course Level:** Consider individual modules within the BIM program and how they incorporate PBL elements, e.g., the "Digital Principles and Standards" (DPS) module includes research activities.
- **Cross-Course Level:** Examine how different modules within the BIM program build upon each other and support project-based learning, particularly the link between the "Research Methods," "Work-Based Learning," and “Dissertation” modules.
- **Curriculum Level:** Evaluate how PBL principles are integrated as a key learning method across the entire one-year intensive BSc (Honours) BIM program.
- **Project Level:** Analyse the significant research dissertations and work-based learning components as substantial projects utilising PBL methods.

**Resonance with PBL Challenges:** The study could explore whether the challenges embedded in the design and delivery of the course, or experienced by its students and staff, align with Chen et al.'s categories:

- **Individual Level:** Consider the challenges students face as individuals working in BIM environments.
- **Institutional Level:** Investigate any lack of support from the institution (though the sources suggest strong institutional support at TU Dublin for BIM education and research) and challenges in designing an effective PBL curriculum.
- **Cultural Level:** Explore further how the Irish AEC sector's context and cultural factors influence the implementation and effectiveness of PBL in the BIM course.

# 7 Conclusions

To summarize, integrating collaborative technologies is central to this BSc course in BIM/Digital Construction, directly addressing the need for enhanced collaboration within Ireland's AEC sector. This course provides mature students with hands-on experience using tools such as Revit, Navisworks, and BIM360 to foster multidisciplinary teamwork and prepare them for the collaborative demands of digital construction. Building upon this foundation, future research is essential to evaluate the effectiveness of these pedagogical approaches and technologies in nurturing leaders and driving the ongoing digital transformation of the Irish AEC industry.

# 8 References


Bhonde, D. (2023). *Understanding the changes resulting from the virtualization of BIM-enabled collaborative design processes in the building construction industry* (Doctoral dissertation, University of British Columbia).

Black, J. S., & Gregersen, H. (2013). *It starts with one: Changing individuals changes organizations*. Pearson Education.

Chance, S. (2024). Active learning to enhance the architecture, engineering, and construction sector. Paper presented at the 16th International Symposium on Project Approaches in Engineering Education (PAEE) and 21st Active Learning in Engineering Education Workshop (ALE), San Andreas, Colombia, July 2024. ISSN 2183-1378

Chance, S. M., & McAuley, B. (2023a). Infusing research know-how into the construction sector: Pedagogies to support digital construction in Ireland. Paper presented at the 2023 ASEE Annual Conference & Exposition, Baltimore, MD, June 2023. https://doi.org/10.21427/B7WA-5W45

Chance, S., & McAuley, B. (2023b). Preliminary mapping of bachelor's research to enhance digital construction in Ireland. Paper presented at the 51st Annual Conference of the European Society for Engineering Education (SEFI), Dublin, Ireland, September 2023.

Chen, J., Kolmos, A., & Du, X. (2021). Forms of implementation and challenges of PBL in engineering education: a review of literature. *European Journal of Engineering Education*, *46*(1), 90-115.

Fullan, M. (2007). *Leading in a culture of change*. John Wiley & Sons.

Grego, A., Chance, S. and McAuley, B. (2023). *Using BIM to increase the efficiency of energy - driven retrofitting projects*. Proceedings of the EUBIM 2023 - BIM International Conference, Valencia, 17th - 20th May, Pp 142-151, DOI: 10.21427/YPBK-9M63

Martin, M., Boch, A., & Furlong, K. (2021). Can the implementation of Building Information Modelling (Digital Construction) improve delivery of Capital Projects (Design and Construction) for the Health Service in association with the development of a new National Estates Information System? Proceedings of the CitA BIM Gathering 2021, September 21-23 in Dublin, Ireland.

McLoughlin, J. & McAuley, B. (2022). Optimising existing digital workflow for structural engineering organisations through the partnering of BIM and Lean processes, Proceedings of the Civil Engineering Research in Ireland 2022 conference, 25-26th of August, Dublin, pp 159 – 170.