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Preliminary Mapping Of Bachelors' Research To Enhance Digital Construction In Ireland

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PRELIMINARY MAPPING OF BACHELORS' RESEARCH TO ENHANCE DIGITAL CONSTRUCTION IN IRELAND

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ABSTRACT

This paper presents preliminary analyses to assess the content of student research conducted through a digital construction course offered to engineers and built environment professionals in Ireland since 2020. The course aims to upskill employed, mature students with a one-year intensive study period in Building Information Modelling (BIM/Digital Construction), and ultimately enable them to earn an honors-level Bachelor of Science degree. Obtaining this degree requires the student to produce a research dissertation, and the course helps students use research and research-thinking to answer pressing questions they encounter in the

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Architecture, Engineering, and Construction (AEC) context. The paper briefly discusses context of Technological University Dublin's BIM courses, the rationale behind offering these courses, and how they address the shortage of BIM knowledge in Ireland. Work reported in this paper involved the collection of the full text of all BIM BSc dissertations and preliminary, systematic content mapping—using titles and keywords provided by the student authors—to identify themes across the body of 59 BIM BSc dissertations submitted to date. This foundation will support subsequent work to assess the quality and usefulness of research from the BSc as well as MSc BIM courses, and BIM research published by university staff.

1 INTRODUCTION

This paper provides preliminary analyses as a step toward assessing the value—to industry and society—of student research conducted via a bachelor's level digital construction course offered in Ireland since 2020. The course at Technological University Dublin (TU Dublin) provides employed, mature students with a one-year intensive study period (60 ECTS over 12 months) that runs alongside and interweaves with their daily work in Architecture, Engineering, and Construction (AEC) and ultimately yields the student an honours-level Bachelor of Science (BSc) degree (Level 8 on the Irish credentialing framework).

This BSc in Building Information Modelling (Digital Construction), aims to upskill individuals and inject new knowledge and skills across the Irish construction sector, enabling more effective practice regarding Building Information Modelling (BIM) and BIM Management (BIMM). BIM and BIMM are tools for creating and managing digital graphic representations and textural data regarding physical and functional characteristics a building or assembly. They are vital for AEC practitioners to learn, as they promote efficiency, reduce errors and inconsistencies, and drive innovation in design, construction, operations and maintenance phases of a project, thus contributing to a more sustainable and productive construction industry.

Obtaining a Level 8 degree in Ireland requires the student to produce a research dissertation, and this BSc course helps students use research skills and research thinking to answer pressing questions they encounter in the AEC context. Whereas our previous paper [1] summarized existing research on BIM education as context to situate this study in the literature, this paper provides a preliminary analytical mapping of the topics explored via formal research methods by our BSc level students over a three-year period.

The overall study of which this is part will help us assess quality and usefulness of research emanating from the BSc BIM course, identify pertinent themes across the set, and identify gaps or shortfalls in our coverage. This can help focus work more productively in the future, as we compare students' work with the prior studies of what has been researched by academics in Ireland [2, 3]. The work will support a larger effort to assess the degree to which BIM research produced at all levels in this institution (by BSc, Master's, and PhD students as well as academic staff) is helping

meet industry and societal needs, enhance the use of BIM in Ireland, and facilitate change across Ireland's AEC sector.

1.1 Prior work supporting this study

As noted above, this proposal builds upon preliminary work, published via the American Society for Engineering Education, on "Infusing Research Know-How into the Construction Sector: Pedagogies to Support Digital Construction in Ireland" [1] which explained existing strategies for the implementation of BIM at national levels, and pedagogies that can be used to support this shift toward digital construction. The paper started by discussing BIM adoption globally, the increasing use of BIM in Ireland, and the need for BIM education in Ireland. It then explained why research is needed to move the adoption of BIM forward and discussed how student research can support implementation of BIM in industry. It next described TU Dublin's scaffolded approach for supporting student researchers, and proposed a general plan to systematically map all BIM research produced at this institution.

1.2 Background on the university's BIM courses

TU Dublin, one of the leading BIM education providers in Ireland, offers BIM courses that teach students how, among other things, to conduct publishable research studies to enhance the AEC sector in Ireland. The university has a Master of Science (MSc) degree program in applied Building Information Modelling and Management (aBIMM) in addition to the honors BSc in BIM/Digital Construction. The BSc and MSc degree courses, housed within the School of Surveying and Construction Innovation, use a scaffolded approach to support students in learning research skills.

Both courses require students to draw from and generate formal research. BSc research at TU Dublin provides a synthesis of existing publications on a topic of relevance in Ireland, resulting in a research paper to a "starter" conference paper standard. In the three years under review, the students had an eight-week course on basic research skills where they developed a plan for conducting their research (generating a research question and aligning it with three objectives, supported with specific methodologies) followed by one semester to conduct the study and write the dissertation. Given this short period of time, students were advised against conducting interviews or surveys but this was assessed on an individual basis. Nevertheless, some of the work is seen as valuable to the wider industry and some studies have been brought forward for presentation and publication at conference [4-6]. Beyond the BSc, BIM research produced by TU Dublin students and teachers includes conference papers, industry reports, and MSc and PhD thesis studies.

1.3 Rationale

TU Dublin's BIM courses help address Ireland's recognized deficit in number of BIM-knowledgeable construction professionals. The courses provide working practitioners with experience using BIM in the context of discipline-specific modelling and multidisciplinary coordination. BSc research projects encourage students to implement a proposed solution to an industry-relevant context or within their

organization. For the BSc, taught modules titled "Work Based Learning" and "Research Skills" help students identify and define industry-related problems relevant to their organizations that can be explored using formal research methods. Explicit goals are that the research output be relevant to the student's employment setting, foster their career development, support their life-long learning and self-directed enquiry, and bring new ways of distilling answers into practice, thereby infusing industry with research know-how plus the BIM skills related to modelling, collaboration, communication, project management, and reflective practice. By equipping BIM students with research skills such as problem framing, literature review, and synthesis, the courses aim to develop future leaders for the field of BIM.

Engaging in BIM-related research projects BIM can help students develop their understandings of BIM technologies, standards, and processes as well as potential advantages of the technologies, how to collaborate effectively across sub-disciplines of AEC, and how to identify and address the challenges faced by industry stakeholders in adopting BIM. Students who are working in the AEC industry while they study can immediately share their new knowledge with colleagues as they apply it in practice.

With the BIM BSc course, launched in February 2020, now firmly in place and producing graduates, now is an optimal time to study and assess the quality and usefulness of our BSc research outputs. Our initial exploration will lay groundwork for subsequent, more extensive study of all BIM research generated at TU Dublin.

2 METHODOLOGY

This paper represents a second step in a larger study to systematically map and rigorously analyze all BIM-related research documents produced at TU Dublin, the first step being a review of pertinent literature [1]. The overall study uses practices for systematic mapping identified by Booth and Grant [7] and, within engineering education research, by Saunders-Smits and Cruz [8].

The methodologies employed to date have included narrative literature review [1], collection of all BSc dissertations submitted for graduation, import of this BSc dataset into NVivo, and preliminary analysis of the BSc titles and keywords. After importing the files, we ran NVivo a query to determine word frequency across the keywords and titles, including stemmed words. Then we tabulated the results of all terms occurring five or more times. We critically analyzed the results, assessing each term identified by NVivo and looking to see where there were overlaps based on the wider content where the term appeared. This allowed us to group terms, and begin to see themes and levels of concentration in coverage of various topics. For this paper we assessed the titles and keywords of 58 dissertations (we note that one dissertation was not formatted properly for inclusion in this analysis as it did not provide a title, keywords, nor abstract).

3   RESULTS

NVivo-indicated the most frequently used works were variants of BIM, a finding that is unsurprising. Fifty-five of the students used Building Information or BIM in their title or keywords. The other terms used with highest frequency were: construction (33 counts, used in the title and/or keywords of 17 students), implementing (17 used by 13), management (17 by 8), Ireland (16 by 14), lean (16 by 7), HBIM (14 by 7), and design (13 by 10). Figure 1 provides a cloud of word frequencies.

Fig. 1. Word cloud of most frequent words, considering titles and keywords only

Drilling down and assessing how each of the terms was used in context allowed us to identify themes, or areas of concentration in the work, as shown in Table 1, which highlights meaningful concentrations of topics. We see that 20 of the students had a major focus on national-level issues—frequently applying research on other countries to the Irish context. Many dissertations focused on implementing or adopting new processes or workflows in construction, and using new tools and software, particularly in architecture and design. Students showed concern for improving industry, especially practices in small and medium sized enterprises (SMEs), implementing lean and efficient practices, and using BIM in facilities management, heritage conservation, modular prefabrication, energy retrofits, and data centers (as Ireland has a high concentration and growing number of such centers). Other commonly investigated topics involved the public, digital engineering, integration, benefits and barriers, automation, collaboration, technologies, structural design, and cost.

Table 1 shows the terms in descending order based on the total number of students using the term in the title or abstract.

Table 1. Most frequent BSc dissertation topics

term	# students	occurrences
BIM or Building Information	55	228
Ireland or Irish	20	23
Construction	17	33
Implement* or adopt*	17	26
Process* or workflow*	17	20
(BIM) Tools, software, or Revit	15	23
Architectur* or design	11	20
Sector or industry	10	12
SMEs or enterpri*	9	6
Lean or efficient	8	18
Facilities [or] management	8	15
HBIM, heritage, historic, or conservation	7	35
Prefabrication or modular	5	13
Energy or retrofit*	5	13
Visual programming	4	15
Data cent*	6	13
Public	6	9
Digital	6	8
Engineering	5	6
Integrate*	5	5
Benefits	4	7
Barriers	4	7
Automate	4	5
Collabor*	4	5
Technolog*	4	5
Structural	3	9
Cost	2	5

4 CONCLUSIONS

We believe that research and reflective practice are essential for the evolution of the digital construction field and that research generated by students and academics at our university is enhancing the knowledge base in Ireland. We further believe that learning to conduct research helps make students more effective practitioners they grow in skill and confidence and start to visualize themselves as leaders. They contribute in new ways to their companies and to improving the practice of construction in Ireland. The analyses presented in this paper constitute one step toward helping us verify the value and research of the BSc course, and confirm the success of teaching BIM BSc students how to conduct research.

Work conducted to date provides a straightforward mapping of the terrain. Later steps will include analysis of the abstracts produced, objectives stated, and methodologies utilized by students, to include MSc in addition to BSc thesis work. Most prior BSc studies have synthesized existing literature to generate new knowledge—for the student and for society at large—by integrating across sources, and also comparing and contrasting existing cases. Many of the students have generated new models, workflows, frameworks, or processes as a result of comparative study. Others have chosen to apply synthesized literature to a new case; and a number of students have employed action research methodologies. Overall, literature review, case study, and action research have been the primary methodologies used.

Of the 59 BSc dissertation studies completed since the 2020 course launch, three have been further developed, presented at conferences, and published in proceedings [4-6]. One generated a new framework to achieve energy-efficient design [4], one optimized a workflow to facilitate structural design [5], and one made recommendations to enhance Ireland's estates management within the health care sector.

The reported analysis of BSc work will inform our subsequent, larger study—a systematic review of all BIM research originating from TU Dublin which will assess coverage of topics, identify gaps, and evaluate the quality and usefulness of the accumulated work. This particular mapping of BSc documents has enhanced the research team's skill in applying systematic review methodologies to help us achieve higher aims in the future. We will subsequently critique the quality and depth of research produced across this institution, summarize key findings, and generate recommendations for BIM research and BIM industry in Ireland.

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