

2020-8

# BIM Research in Irish Academic Institutions 2015-19

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ABSTRACT: The use of BIM in the Irish construction industry has become pervasive in the last decade and it is an essential element in improving productivity in the market. The developments in BIM education and training in supporting the increase in Ireland's BIM maturity has been well documented in recent years, principally through the proceedings of the BIM Gatherings and the BIM in Ireland 2017 and 2019 reviews. Similarly, the public and private sectors have been surveyed to establish their readiness for digital transformation on their BIM journey. However, BIM research undertaken by Irish academics, while individually strong, has not been strategic at national level nor has it yet met all the needs of industry. This paper will review the learned publications of all research-active academics on this island in the various aspects of the field of BIM-related research in the last 5 years. It will categorise and analyse their achievements, acting as a national reference source for all parties in this industry. It will also suggest areas where further research opportunities exist in support of the continuing fast-paced evolution of this digital technology in the construction industry, nationally and internationally.

KEYWORDS: BIM Gathering, BIM research, Academic institutions.

## 1 INTRODUCTION

The use of Building Information Modelling (BIM) as a collaborative tool between all the parties in the construction industry has arguably been the single most significant technological change in the last decade [1]. The extent of the diffusion of this technology into the industry has been clearly evaluated in a BIM in Ireland 2017 report [2] under the BIM Innovation Capability Programme (BICP) funded by Enterprise Ireland, supplemented by an update in 2019 [3]. In these publications, a review was presented which mostly focussed on the penetration of BIM into industry and education. However, there was not a strong focus on research, the backbone of any technological development, but research (and industry) has been very well served by a series of BIM Gathering conferences organised every two years since 2013 by the Construction IT Alliance (CitA) [4-7]. This has become a platform for industry, education and research communities to showcase their BIM activities through a published set of proceedings. The best papers from this conference series were published in the International Journal of 3-D Information Modelling. However, no concise and collected list of research publications in BIM-related research, as pertaining to the 3rd level institution activities, has been compiled until now and this paper sets out to rectify that absence.

## 2 METHODOLOGY

A method for research publication gathering has been successfully employed in another sector of the construction industry, namely that of concrete technology. Through investigation of all conference and journal papers published by academic authors from all third level institutes on the island of Ireland, a comprehensive list of over 650 concrete–related papers were categorised and analysed in 2015 [8], with a further 150 papers reviewed in 2018 [9] and these have become a national reference source for the concrete community since then. Indeed, advice has been offered [10] on how to conduct a BIM research survey.

For this paper, with the advantage of the knowledge of the active members of the Irish BIM Academic Special Interest Group, a contact point in each of the academic communities in the Universities and Institutes on this island, as listed in Table 1, was requested to furnish the authors with a list of their colleagues' peer-reviewed publications in the five year period from 2015 to 2019 inclusive, excluding theses and business reports. Note only BIM papers from disciplines in construction, not computer science, were sought. From these, a database of publications has been created in a series of categories so that a narrative can be generated to reflect the wide extent of BIM-related research on this island.

Table 1. Key contact list in the third level institutions.

| Institution | Contact name | Institution | Contact name |
|---|---|---|---|
| Athlone IT | Finola Deavey | Sligo IT | Daniel Clarke-Hagan |
| Carlow IT | Eoin Homan | Technological University of Dublin | Barry McAuley |
| Cork IT | Ted McKenna | Trinity College Dublin | Roger P. West |
| Dundalk IT | Eamon Cushnahan | University College Cork | Denis Kelliher |
| Galway-Mayo IT | Mark Kelly | University College Dublin | James O'Donnell |
| Letterkenny IT | Anne Bonner | University of Limerick | Javier Buran |
| Limerick IT | Paul Vesey | University of Ulster | David Comiskey |
| Queens University Belfast | Tara Brook | Waterford IT | Gordon Chisholm |

An analysis shows that there are 124 learned publications reviewed in this paper, of which just over 80% have been conference publications. Interestingly, 57% of those were published in the BIM Gathering conference series, indicating the important role of this initiative by CitA as an avenue for research expression in Ireland. Furthermore, about 25% of all journal papers were published in the International Journal of 3-D Information Modelling, as a consequence of being selected as the best papers at the BIM Gathering series.

The papers were gathered and categorised and the outcome is a short statement on the key publications identified in this survey. The survey may not be exhaustive because the completeness of the reference lists depended on the responsiveness of the individual academics themselves, but all 16 academic institutions contacted (Table 1) made a return.

## 3 NATIONAL MATTERS

### *3.1 Public Sector and Government*

It can reasonably be argued that the practical use of BIM has been industry-led [7], but it is vital that the government in Ireland adopts BIM for its public contracts as soon as practicable. To this end, some observations on the adoption strategy [11], framework [12] and policy objectives [13] needed to achieve this have been made. The collaborative nature [14] and procurement strategies [15] to be adopted in the public sector have also attracted attention.

### *3.2 Standards*

Putting in place standards to regulate the industry is no less important for BIM than it is in other aspects of the construction industry and some useful work has been done in this regard [16, 17], considering international best practice. With the introduction of the new ISO 19650 standards, this aspect of BIM's introduction will have to be complied with, so industry will have to adapt quickly using these standards directly, given the sparsity of academic research and guidelines in this area.

### *3.3 Readiness*

A key question in imposing a national BIM mandate for public projects is how prepared and capable is the Irish construction industry for BIM level 2 implementation, recognising the high percentage of SMEs which exist in the industry. The BIM Innovation Capability Programme (BICP) established, in 2017, the state of readiness of the Irish construction industry, where it was established that there were weaknesses, especially in policy, procedure and training [18]. By studying the international trends in BIM adoption [19, 20], lessons could be learnt from other jurisdictions, while simultaneously establishing Ireland's BIM maturity and diffusion [21, 22], thus formulating a roadmap for managing the complex change which adopting BIM will inevitably entail [23].

### *3.4 Roadmap*

This research on maturity and readiness was fed into the National BIM Council (NBC) who developed a national roadmap for BIM adoption and digital transition [24]. Concerns have been raised about maintaining the momentum in executing the roadmap [25], especially the funding and development of a Centre of Excellence on which future BIM research will depend so much [26]. Without such an initiative by the government, future BIM research will be more likely to be ad hoc and uncoordinated, as at present.

## 4 INDUSTRY SECTORS

Academics generally do research in areas of their own expertise by seeking out funding for postgraduate students to assist with their work. Therefore, much of the BIM research has been in quite specific areas, not necessarily aligned to a national strategy but grounded in applied problems related to various technologies available or emerging within industry. This section of the paper largely reflects this diversity of approach.

### *4.1 Design*

Defining what a design model is in the new BIM context is a good place to start [27], recognising the key role of BIM collaboration in relation to practice [28]. In particular, at early stages in design, the establishment of the design intent [29] and, later, the employer's information requirements (EIR) are both evolving services designers provide in developing an IT model for the design, construction and operation/maintenance of buildings. The concept of intelligence –assisted building design and management [30, 31] is interlinked with developing a virtual BIM model of the project.

### *4.2 Quantity Surveying and 5-D BIM*

As have other parties in construction, the quantity surveying profession has had to take the ubiquity of IT in construction on board extensively in their daily practices [32]. For example, the role of digitisation in the strategic planning process has been investigated [33], as has the client-driven life cycle costing of projects in the so-called 5-D BIM [34, 35]. In particular, the use of 5-D BIM as a collaborative tool with better interoperability leading to improved efficiencies for Quantity Surveyors has been noted [36, 37].

### *4.3 Facilities Management (FM)*

Inevitably, life-cycle analysis is not only the bailiwick of the quantity surveyor – the "life-cycle engineer" is more under the auspices of a facilities manager [38, 39], where future operational efficiencies have taken on a new and deserved importance. The early involvement of the Facilities Manager in the design process is a notion that several researchers have investigated, identifying what value can be added and what key tasks can be usefully employed in design development [40 – 44]. Through the use of BIM specific FM software [45], big data can thus be used to develop more efficient, smarter buildings [46, 47].

### *4.4 Construction Management*

Multiple authors have published on the implementation of a wide range of construction site related BIM research [48]. Papers in areas as diverse as fire safety compliance [49], record keeping [50], information transfer [51], knowledge management [52] and on-site performance [53] have been published. Infrastructure delivery has also received attention [54], including the application of BIM to road construction [55]. An approach to developing a managerial system to implement BIM has also been proposed [56].

### 4.5 Case Studies

CitA developed a large suite of Irish BIM case studies [57] which is a useful resource for those commencing their BIM journey. Some authors have used case studies (use-cases) as vehicles for their research. Pure cases include large building projects such as the National Children's hospital or the Grangegorman development [58, 59], the need to convert BIM theory to practice in a short timescale [60, 61], or more specific cases of BIM's contribution to lean construction [62] and environmental impacts [63].

## 5 SPECIFIC ASPECTS

There were also clusters of research in a number of specific aspects of BIM research worthy of mention, as follows.

### 5.1 Lean Construction

While lean construction covers an extensive range of topics and technologies, there is undoubtedly a facet of the efficiencies brought about by the use of BIM which bears examination under this heading. However, despite the significant research potential and current doubts about value for money in employing BIM, only four papers have been published in this area. Three of these are useful starting points because they review the potential lean aspects of BIM adoption for architects and SMEs [64-66], while the fourth is very specific: the viability of using BIM as a lean technique in office fit-out projects [67].

### 5.2 Energy

Energy provides the first real evidence of a BIM research cluster, with 17 papers published in this category. Building performance simulation is a popular topic [68-76], where integration and information exchange [68-70] and modelling [71-72] are important in their interaction with BIM models [73-75]. Point-cloud mapping and low-resolution photography are also increasingly important tools for generating data for input into a BIM model [76, 77]. The use of geospatial techniques to link data into BIM has been an international initiative [78] and have been used on multidisciplinary [79] and retro-fit projects [80].

The development of energy performance assessments methods [81, 82] leads to the ability to optimise building performance virtually [83], leading further into the development of models for thermal comfort [84, 85], an area receiving a lot of attention in the context of the carbon agenda. Improving sustainability by delivering energy savings using BIM has been the objective of a European initiative to award a qualification for those suitably trained in this area [86, 87].

### 5.3 Blockchain

BIM and Blockchain have been used in tandem to incentivise multidisciplinary teams to trust each other in procurement practices [88 – 90]. It is an emerging technology in construction and has significant potential.

### 5.4 Historic BIM

Historic BIM (HBIM) is also a growing area where BIM is used to model historic buildings with a strong international dimension [91, 92] and which translates well into Ireland [93]. Intelligent modelling methodologies can be applied to the built heritage [94] on esoteric projects as diverse as conservation, to a viaduct, to an observatory [95-97]. Again, given the need to preserve the national built heritage, there is abundant scope for further research and application in this arena.

### 5.5 Digital Twin

The emergence of the importance of a digital twin arises from enhancing value to clients for their investment in BIM at the early stages. With vast amounts of data being generated in BIM models at every stage prior to handover, the selective extraction of useful data post occupancy is vital to developing a practical digital twin for the operation/maintenance stage in the life cycle [98]. Dynamic building performance in use leads to better predictions and simulations so that change during operation can be optimised [99, 100]. Much more will be made of this into the future.

## 6 EDUCATION

While most papers under review are associated with aspects of research into practical topics within industry, as described heretofore, there is also a wealth of experience in research into BIM in education, as evidenced by the 29 papers [101-129] described in this section. The BIM in Ireland 2019 review showed that Irish education ranks amongst the best in the world in the adaptation of its construction-related programmes for BIM, ranging from inclusion in undergraduate design modules through to full MSc and industry training programmes [3].

### 6.1 Learning Development

By looking elsewhere in the world [1, 101], a culture of facilitating rapid change has brought about a massive transformation in Irish education [102]. The pedagogical philosophy of introducing BIM into curricula has been explored [103, 104] with asynchronous learning and collaboration with the college's estates departments for use-cases being proposed [105-107]. The infusion of BIM into undergraduate [108] and postgraduate [109] courses and modules have been showcased in structural engineering [108], quantity surveying [1089 110] and construction [111]. In this, one can learn from others situated elsewhere in the world [112]. Ultimately this leads to pathways to employment in the market place [113] and the attributes of graduates and their BIM-readiness for industry are matters of increasing interest.

### 6.2 Collaborative Learning

One of the principal opportunities afforded by introducing BIM into 3rd level modules is for collaborative learning – engineers work on problem-based tasks with quantity surveyors and architects; or civil with mechanical and electrical engineers [114]. There are several exemplars of international collaboration between Irish third level institutes and other non-Irish universities [115-118]. Several others have well-

developed collaborative partnerships with industry [119-122]. Others still, more specifically, have established collaborative data sharing platforms and multidisciplinary frameworks [123-124]. Participants on these programmes will probably be better prepared for the multidisciplinary collaborative environments which BIM engenders in practice.

### *6.3 Education by Discipline*

In Civil and Structural Engineering, it was interesting to know of the successful introduction of BIM into undergraduate curricula [125, 126]. Similarly, in Quantity Surveying and Facilities Management [127, 128], the benefits of incorporating BIM into modules of such courses, including students working with live estates management projects on campus [129] , is a notion that could be expanded to other institutes, though the evidence is that they are well-provided for in this regard [3].

## 7 MISCELLANEOUS

The cultural shift required for industry to adopt BIM is not without its challenges. Several papers have highlighted relevant factors; client-consultant trust [130], management aspects [131] and lessons learnt from perceived changes in the UK [132].

There are persistent and new legal issues arising from introducing BIM, which has not received enough research attention [133].

IT-based BIM–supported knowledge management is also a matter deserving of more research [134, 135], as is e-procurement [136] and compliance checking [137], all rich avenues for further investigation.

## 8 CONCLUSIONS

A snapshot of the extent of BIM research on the island of Ireland has been provided in this paper. It is noteworthy that almost 60% and 25% of all conference and journal papers respectively have been sourced from initiatives undertaken by CitA. There are two key observations to be drawn from this; Namely that continued funding for CitA is vital for Irish research at a time when the financial impacts of Brexit and the Covid-19 virus are going to be harshly felt by the industry; Secondly, it is important that Irish academics are also encouraged to travel to international BIM events to share and gain knowledge – such a heavy reliance on domestic conferences is not necessarily healthy. A further observation can be made in the disparity of topics in BIM research and this largely emanates from not one institute or College having the critical mass to be a strong, internationally competing BIM research centre – indeed the strongest BIM research category in this review is related to teaching and learning which imposes limitations in respect of leading industry to the next stage of BIM's evolution. The continued absence of a national Centre of Excellence does not help in this regard.

Nonetheless, for a country of our population, there exists an active BIM research community in which continued initiatives and efforts reflect very well on the island's BIM academic capability, as evidenced by the volume of research undertaken during 2015-19, in an environment of parsimonious funding.

Finally, hopefully this paper will be a useful reference source for students, academics and industry alike over the next 5 years or so.

## ACKNOWLEDGMENTS

The assistance of the listed academics, from the 16 institutions in Table 1, in sourcing the data presented in this paper is most gratefully acknowledged.

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