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Establishing the key pillars of innovation required to execute a successful BIM strategy within a Construction SME in Ireland

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ABSTRACT

The recent resurgence of the Irish Construction Industry comes at a time of global transition towards an information revolution, with technology now playing a vital role within our post-recessionary society. BIM is now seen as a core technology at the forefront of this transformational change which can present Construction SMEs with opportunities to new financial ventures. If any SME organisation is to be successful with BIM adoption then innovation must be the starting point. The aim of this paper is to establish the enabling factors required for innovating a BIM strategy within a SME Construction Organisation. The methodology involved a critical in-depth desk top study which was complimented through a series of interviews with SMEs based within the Irish AEC Sector. The interviews examined current attitudes, BIM maturity and organisation barriers with respect to the enabling factors of BIM innovation for SMEs. The research highlights that if these enabling factors are successfully addressed then BIM has the potential to in-crease consumer expectations, offer greater exposure to larger and more profitable projects. The research findings further demonstrate the need for a clear and simply understood BIM adoption Strategy amongst SMEs. However, to fully innovate BIM processes the major factor required is for the Irish Government to mandate BIM which will assist in driving SMEs forward.

Keywords – BIM, SME, Barriers, Innovation, Ireland

I INTRODUCTION

The recent resurgence of the Irish Construction Industry comes at a time of global transition towards an information revolution, with technology now playing a vital role within our post-recessionary society. There is a need for construction professionals to embrace new technologies and adapt out-dated, fragmented work methods into a collaborative approach through building information technology. Building Information Modelling (BIM) is now seen as a core technology at the forefront of this transformational change with the global market for BIM expected to reach \$7,946 million by 2020 [1]. Adopting a BIM strategy presents Construction Small and Medium Enterprises (SME) with both opportunities and challenges that can offer new financial and creative opportunities for most construction related organisations [2]

With the ever-increasing adoption of new technologies SMEs will now need to provide a service that incorporates innovative processes, such as BIM. Innovation can be described as; a change that happens in a planned manner, new processes, new procedures or new way of organising, from the tiniest improvement to the radical rethink innovation can have an important contribution to organisational success [3]. If any company is to be successful with BIM adoption then Innovation must be the starting point. This paper will explore the key factors and enablers required by SMEs who wish to innovate.

II THE IMPORTANCE OF SMEs LOCALLY AND INTERNATIONALLY

SMEs account for 99.7% of all enterprises and 68% of all employment [4]. These figures are further enforced through the realisation that in 2008 approximately 95% of Irish enterprises had less than 10 employees, which has now increased to 97.5% by 2014. A concerning trend has emerged within the Irish Construction Industry which highlights that from 2008 medium to large companies have downsized, while small new enterprises with few employees have grown [5].

The high density of SMEs through Europe further expands on the importance of these organisations, with the European Builders Confederation highlighting that 99.9% of the European Construction Sector is made up of SMEs with an average of 4 employees [6]. European Construction SMEs are currently discussing how to adapt BIM and have stressed that it “must be SME friendly if it is to trigger deep innovation in Construction” [7].

Similarly, the Canadian Construction Industry have also reported that small businesses represent 99% of the employer in the Canadian Construction Industry. Recent figures also show that in the United States 59% of companies have less than 5 employees. These figures demonstrate the importance of SMEs within the wider economy and specifically within the Construction Industry, as a whole locally and internationally [8].

Although Construction SMEs have limited access to investment capital and operate under resource constraints they are better positioned to innovate than larger firms. SMEs flexibility, their simple organizational structure, their speed in decision making are the essential factors that allow them to innovate [9]. SMEs can generate, develop and deliver significant technical innovations due to the level of control that a manager has over decision making [10]. SMEs can position themselves to make decisions quickly, allowing them to be the first to market with innovative ideas, with larger organisation possibly taking months or years evaluating new ideas and passing them through multiple departments before a decision is made [11].

III BARRIERS FOR ENTRY FOR SMEs

Despite their unique position to innovate Construction SMEs face a number of barriers and challenges. These include:

1. **Access to Finance:** Over the last number of years the SME sector has faced more difficulties than any other in accessing finance from banks. Construction SMEs are considered to be a higher risk due to low levels of fixed capital and smaller firm size [12]. Many firms have limited financial scope to invest in current and future digital technologies and capabilities [13]. The ability of Construction SMEs to access the right type of finance is crucial for SMEs to operate, sustain and grow.
2. **Cultural Change:** A move towards BIM Capability and expertise requires firms to re-evaluate and re-engineer their business practices, while also highlighting that cultural business change is another challenge for firms [14]. An industry reluctance to change, a ‘wait and see’ approach is slowing the inevitable uptake of BIM in the AEC industry [15]. With the Industry being so large, dynamic and the tradition of Construction SMEs it becomes harder for everyone to become innovative to change a culture or habit.
3. **Poor levels of Communication and Information exchange between parties in the construction process:** Traditionally stakeholders represent different professions with a set of multidisciplinary skills that can limit the scope of co-operation between them [16]. Even with the adoption of ICT within an organisation problems still exist. A significant problem is the lack of understanding of how to implement ICT into a construction organisation [17].
4. **Adopting Technology:** Information technology represents a paradigm shift with respect to the transfer and management of information. Adopting a new technology always involves significant investments [18]. There can be many barriers to keeping project participants from using the latest technologies including fears of low success, failure, high initial investment costs, the time to learn how to use the software, and most of all the lack of support from senior leadership of the company [19]. The role of ICT within the construction industry can be a barrier to SMEs keeping up to date with the latest advanced BIM tools.
5. **Resources/Training/Skilled Staff/Lack of Knowledge and skills:** The obstacles in small markets are greater, where design and construction companies do not have enough resources to obtain and maintain theoretical BIM methodology [20]. Most SME companies do not have the resources to gain access to the relevant information and acquire the knowledge and skills to investigate and research new innovation processes or tools.

6. **Construction Project Coordination:** The lack of coordination between construction supply chain parties is one of the key reasons for poor performance in the construction industry [21]. Coordination plays a crucial role throughout the building process especially during the design and construction stages
7. **Procurement/Standards/Legislation and Bureaucracy:** Excessive bureaucracy or red tape imposes a disproportionate bureaucratic burden on small and medium size enterprises [22].

IV KEY PILLARS OF INNOVATION WITHIN CONSTRUCTION SMEs

With the rapid technological progress and increased competition amongst SMEs, they are being forced to innovate and launch new successful products and services to sustain their advantage over competitors, while also being competitive in their relative market. However, innovation is sometimes hard to implement within organisations due to users being required to learn how to use a new innovative product or service and to change the way of work practices. Due to the nature of Construction SMEs the Industry is perceived to have low levels of innovation compared with other sectors due to high levels of industry fragmentation.

For BIM to grow within SMEs, they will need to innovate. In the Construction Industry, innovation has been recognised in three domains: product, process and organisation [23] These are three key elements as to what the product is, the new processes involved in implementing innovation and the role of the organisation innovating.

Hardie et al. identifies and formulates construction innovation in a value tree, see figure 2, which identifies enabling factors of construction innovation [24]. The value tree represents a synthesis of the variety of influences that may have an impact on the innovation delivery process. The variety of influences are categorised in 5 distinct factors to innovation in construction SMEs, such as Company resources, Client and End User, Project Based Conditions, Industry Network and Regulatory Climate. Within these five distinct factors are sub-factors which contribute to each distinct factor. The key areas to innovation and how BIM from the perspective of the SMEs targets all 5 areas of innovation is discussed below.

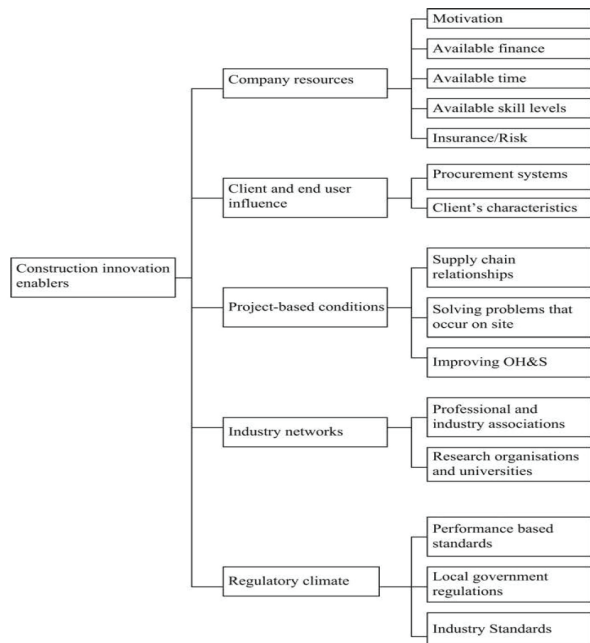


Fig. 2: Value Tree of Enabling Factors – variety of influences on innovation process (Hardie et al, 2011)

1. Company Resources

For any company whether large or small the available resources are critical for innovation success. Company resources incorporate the internal capacity that a company has at its disposal that can be deployed towards the innovation process [25]. The value tree shows sub-elements to Company Resources which highlight a complex mix of required resources. Within the realm of company resources is staff and the motivation of individuals to adapt to innovative processes, services or products. After an organisation adapts an innovative solution such as IT or ICT, that innovation is affected by the degree of motivation or self-motivation of individuals within the company. Peansupap et al. reiterates this by explaining that “during the actual implementation period, IT/ICT use remains dependent upon the individual’s decision whether to accept or reject the application” [26]. Abbott et al. identifies other reasons why people or organisations are motivated to innovate such as “profit motive” or “economic motivation” [27].

Employment of highly disciplined and qualified staff could be an important aspect that could assist in a business’s success. The relationship between employee motivation and creation of innovation exist [28]. Human capital is essential for business innovation and it could have a positive effect on the growth on SMEs. The personnel skills of

employees can significantly influence the development of innovation [29]. Employees with BIM knowledge would have a strong influence on the application of BIM within a small organisation,

The ability of construction sector companies to access the right type of finance is vital for them to operate and grow, however research shows that Construction Contracting SMEs face more difficulties in accessing finance from banks due to size and low levels of fixed assets [30]. The availability of finance is a key component to company resources with financial problems being considered one of the main obstacles for innovation due to low profit margins.

A skilled and flexible workforce is vital for the construction sectors future performance and competitiveness. To successfully innovate BIM within an organisation money, time and skill levels are required.

2. Client and End User

Hardie et al considers that the Client and End Users influence on innovation as another enabling factor of innovation [31]. It is considered that those who pay for projects in construction can have a good deal of influence on innovation within the sector. Public clients such as Governments have a critical role to play in utilising the use of BIM on public construction projects. They can encourage the use of BIM by directing and mandating enterprises to innovate or punishing those unable to tender for BIM projects due to lack of capabilities. To maximise the benefits of BIM, it is vital that the end-users are fully engaged in the design process and that their needs are fully appreciated [32]. The willingness of the client to risk share, commitment to innovation and leadership in reject planning and execution seems to be critical for the success of the innovation process [33].

All clients have different characteristics with one of the primary aims of BIM to improve the collaborative process between all stakeholders through IT collaboration.

3. Project Based Conditions

Behind an organisation implementing an initiative product or process is a supply chain that incorporates skilled personnel, who in many cases hold valuable practical knowledge in the delivery of a product or service. The construction industry has a very large supply chain from professional services, sub-contractors, material suppliers and service

providers. With high levels of fragmentation within the industry the relationship between Construction SMEs and the supply chain is crucial for the delivery of a project. An important factor for the successful delivery of a construction project involves early contractor engagement and continuing involvement of the supply chain in design development. This can build strong relations and provide the platform for effective site management [34].

BIM has the potential to be utilised by SMEs to improve a number of project based conditions, such as production and development of 3D models, co-ordination for clash detection and spatial analysis, quantity take off, facility management and linking specifications to models [35].

4. Industry Networks

Innovation in the construction industry is heavily influenced by the structure of relationships in the industry [36]. Open collaboration among project teams is fundamental to the core understanding of a BIM solution for the industry. However, the very nature of the Irish Construction industry is one of adversity among its stakeholders, where information is closely guarded and knowledge is seen as power [37]. This confrontational behaviour must come to an end if the potential of BIM is to be fully adhered. All stakeholders within the industry network are key enablers of BIM innovation.

5. Regulatory Climate

The highest factor as an enabler to innovation is Regulatory Climate [38]. Consistent national and global standards are necessary to achieve the efficiencies envisioned by technology but it is nonsensical for there to be a large range of different systems and piecemeal approaches to BIM development [39]. Legislative regulation is an important aspect of cultural formulation especially in the construction sector, individuals understand the society through requirements posed by regulations [40]

Regulations within the Construction Industry are a significant enabling factor to innovation. Regulation can hinder or discourage a company from innovating due to excessive “red tape” or as Zimmerman et al. states “the bureaucratic barriers put in place by legislation, legal requirements and standards as well as lengthy administration and approval procedures are a further hindrance” [41].

The role of Governments has a significant role to play in either driving or inhibiting innovation amongst small enterprises. Many Government Departments around the world now see the need for BIM and acknowledge its benefits to project delivery. Governments within the EU recognise the importance of the SME sector and the creative ideas for new and innovative solutions. The circular 10/14 Initiatives to assist SMEs in Public Procurement states that “buyers (Government) should, where possible and appropriate, encourage new and innovative solutions by indicating in tender documents where they are prepared to accept reasonable variants to the specification [42]. Further to this the EU the European Technical Committee (TC 5) has been established to develop the CEN 442 standards which reflect the importance of BIM for participating countries and the need for European standardisation in the BIM area [43]. The involvement of Small Business Standards in CEN/TC 442 is resulting in standards being developed that are focused on the needs of SMEs in how to design a European standardised approach to BIM.

V RESEARCH METHODOLOGY

For the purpose of this paper it was decided to adopt a qualitative research approach in conjunction with interviews. This method of research involves “experiences, descriptions and focuses on human behaviour as it occurs naturally. This will enable the authors to gain a deeper understanding of the attitudes towards barriers, innovation and BIM within Construction SMEs through collating opinions and experiences. The interviews were conducted with four different organisations. The interview participants were of two number SME construction contractors and two number sub-contractors. The four interviewees have experience and knowledge of BIM.

VI PRIMARY RESEARCH

1. *Barriers and inefficiencies faced by Construction*

The first objective was to establish the current barriers and inefficiencies faced by Construction SMEs in the Irish Construction Industry. The Literature review identified key barriers faced by Construction SMEs in today’s AEC Industry including access to finance, changing mind-sets and cultural change, poor levels of communication and information exchange between stakeholders, adoption of technology, the lack of resources, coordination and finally procurement. The primary research highlights that the Irish Construction

Industry is experiencing a dramatic transition from Boom to Bust but is returning to a sustainable level of activity. However, SMEs within the Industry still face constant barriers and inefficiencies. There was a strong link and agreement between the literature and the interview findings with regards to the barriers and inefficiencies faced by SME Contractors.

The lack of experienced and skilled professionals within the industry is having a severe impact on the growth of Construction SMEs. The primary research finds this is the biggest impact and barrier to the industry at present. The Literature highlighted the importance of company resources as being a key enabling factor of innovation. The consensus amongst the interviewees is it could take up to a decade before enough people come out of training and full-time education to meet the demand at present. This is very concerning with DKM in conjunction with the CIF reporting that based on the expansion and replacement demand the total labour required within the industry over the next four years is around 112,000 workers [44].

There are very significant concerns about the availability of workers with the necessary skills to meet this demand. With the severe lack of tradesmen and professionals labour costs look certain to increase. With the lack of technical and skilled people the advancement of new BIM technologies within Construction SMEs is going to suffer. An integral component of BIM is technology, BIM requires software, that software requires skilled employees with ICT knowledge.

Access to finance was another considerable barrier experienced by all in the industry. BIM requires upfront investment from the very start to implement. Access to finance is a real concern for some of the interview participants, which in turn affects the resources a company has at its disposal to innovate.

Each participant highlighted that poor levels of communication is still a regular occurrence in the industry, with stakeholders still closely guarding information. This is concerning as open collaboration among project teams is a fundamental requirement for open BIM. The use of ICT technologies such as common data environments are an important enabler in promoting collaboration between all the project stakeholders. A firm must re-evaluate and re-engineer their business practice if a successful cultural change strategy is to be implemented. Without changing a “culture” or “habit”

Construction SMEs could be left behind by the industry.

2. *The rationale and Barriers for Innovation*

The second objective was to examine are Construction SMEs innovating, the reason for innovating and the factors that maybe impacting on the innovation delivery process of BIM. The literature review highlighted that due to the high levels of fragmentation within the industry the nature of SMEs within the Construction Industry is perceived to have low levels of innovation compared to other sectors within the economy.

It was encouraging to see that all of the respondents have innovated, are innovating or in the process of innovating new processes or tools within their organisations. This shows there is a positive outlook within the industry. However, the interview participants are not looking to completely change their existing practices due in part to the lack of business opportunities offered by BIM processes and tools at present, but are preferring to implement BIM tools and processes in small stages.

The literature review identified the main reasons why organisations innovate i.e. to increase profits, advance technology within the organisation, increasing consumer expectations, etc. These reasons to innovate were all supported by the respondents. However, it was discovered that “exposure” was a further reason to innovate BIM amongst the interviewees. BIM can increase an organisations “exposure” to larger and more profitable projects as well to clients that they wouldn’t have otherwise had access to. The primary research found that profits was not a motivation for implementing BIM at present.

The key factor for the innovation of a process or product such as BIM within an organisation was primarily due to the “Motivation of Directors”. The interviewees believe implementing a BIM strategy has to come from the top management of the organisation. The research shows the leaders of organisations should be the ones to drive BIM innovation and without the motivation of these leaders BIM will not happen.

3. *Benefits and Barriers of implementing BIM for SMEs*

The third objective was to report on the benefits and barriers of BIM within a Construction SME. The literature has highlighted the benefits that Construction SMEs are achieving as a result of BIM.

Each of the respondents highlighted their uses of BIM for different reasons on a project e.g. extraction of quantities, structural analysis, clash detection, off-site construction, sun-casting analysis and to give clients a better understanding of the end product. It was evident from the interviews that SMEs are using BIM in different ways. They highlighted the use of BIM for visualization capabilities and communication of the design intent. 4D BIM uses were also highlighted with the contractors using it for construction site planning related activities. 5D BIM was used for budget tracking, cost analysis and extracting quantities from the models.

Finding skilled and experienced staff was a major barrier of utilising BIM as discussed by the four respondents. Other notable barriers include the accuracy of the models where re-checks on quantities are still being performed.

4. *A requirement for a framework for adopting a BIM strategy within a Construction SME*

The final objective was to discuss whether there is a requirement for a framework for adopting a BIM strategy within a Construction SME. It became evident during the interviews that there is a need for a clear and simplified guideline so SMEs can adopt BIM processes and tools.

The general consensus is that a simplified framework aligned to Construction SMEs for BIM adoption is required. With an improved guideline and framework, innovating BIM processes will not be onerous to the SME community and will assist them in overcoming some of the inefficiencies within the AEC industry.

VII CONCLUSION

The research has established that the productivity gains associated with BIM can be realised by both larger and small enterprises. The recession has presented a number of unique barriers for SMEs who have had to adapt by considering new innovative business models. These new business models must take into account existing barriers which include, amongst others, a lack of open collaboration between stakeholders. The research has highlighted that if BIM forms a fundamental part of this business model then it can assist in breaking down these barriers by encouraging collaboration between stakeholders. To achieve this the SME must be open to change which must be communicated from the top down through an organisational

vision. This vision must also account for the use of important company resources such as finance.

If this is done correctly it has the potential to increase consumer expectations, greater exposure to larger and more profitable projects and to clients that they otherwise wouldn't have had access to. However, to fully innovate BIM processes the major factor required is for the Irish Government to mandate BIM on public contracts which will assist in driving SMEs to adopt BIM innovation. This will provide a standardisation across the industry which will ensure that the key requirement for innovation is provisioned for. Such a mandate must include the correct financial incentives and provisions for SMES or it will risk further alienating them within an already difficult and extremely competitive sector.

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