BIM Education in the Dominican Republic:

A framework to guide the implementation of BIM into university curricula

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ABSTRACT

Lack of BIM skilled professionals and lack of education and BIM training are key challenges to BIM implementation. The provision of BIM education in higher education institutions is seen as the main solution to these challenges. This book chapter is part of an on-going Ph.D. research about the implementation of BIM in the Dominican Republic, a country with interest in implementing BIM but suffering from many challenges including lack of BIM Education. This study aims to present the development of a framework to guide the integration of BIM in university curricula in the D.R. which is part of a comprehensive framework, outcome of the Ph.D. research. The framework was developed from a thorough literature on BIM education as well as an analysis of existing BIM Education frameworks. Moreover, findings of the research about BIM Education in the D.R. are presented to describe the presence of BIM Education in the country.

Keywords: Academia, AEC Industry, AEC Professionals, AEC students, BIM Education, BIM Education drivers, BIM Education Framework, Central government, Higher Education, Public Sector

INTRODUCTION

It is generally accepted that BIM processes and technologies offer significant benefits to construction projects and, as a result, nowadays BIM is progressively seen as an essential aspect of many construction projects. Therefore, BIM competence has become a very important and required skill from AEC professionals (Suwal & Singh, 2018). Contrary to traditional projects, the development of a BIM project demands new skills for all the disciplines, BIM competencies and even company-level BIM capabilities (Puolitaival & Forsythe, 2016). Nonetheless, lack of BIM skilled professionals (Eadie, Browne, Odeyinka, McKeown, & McNiff, 2013; Lee & Hollar, 2013; Wu & Issa, 2013; Gardner, Hosseini, Rameezdeen, & Chileshe, 2014; Lee & Hollar, 2013) and lack of education and training are one of the most impotant barriers hindering the implementation of BIM in the industry (Wong & Gray, 2019). To keep the impetus of BIM, it is necessary to effectively prepare the industry's labour force to respond to current supply-demand (Bozoglu, 2016).

BIM education is seen as the solution to speed the BIM learning curve; thus, future graduates would be BIM-ready when they start their professional careers (Wu & Issa, 2013). Furthermore, Smith (2014) emphasised that BIM education, training and research are vital to propel motivate the implementation of BIM and Sharag-Eldin & Nawari (2010) further considered that education and training are the basis of BIM evolution.

The present study is a continuation of a previous study under the title "BIM Education Framework for Clients and Professionals of the Construction Industry" in which a conceptual framework was created to guide the development of BIM Education strategies in Academia and the industry in order to educate all

the construction parties involved in a project, including the client (Silverio et al., 2017). The conceptual framework was conceived as part of the PhD research "Implementation of Building Information Modelling in the Dominican Republic construction industry", whose outcome is a comprehensive framework to facilitate the implementation of BIM in the Dominican construction industry. The previous work showed the development of the framework, which was based on an extensive literature review on BIM Education and the analysis of several existing BIM education frameworks. Moreover, primary data from the preliminary study, first phase of the Ph.D. research, since the need to study the presence of BIM education in the D.R. and create a BIM education framework was identified at this stage.

This study will follow previous work by first giving a brief introduction about BIM education in higher education. Moreover, previous discussions on challenges of integrating BIM in Academia, approaches to enhance BIM education and the role of both, Academia and the industry in this matter are enhanced. Then, a thorough analysis of BIM education drivers is presented. BIM education frameworks studied for the development of the conceptual framework are also presented, followed by key findings of the primary data from the main study of the Ph.D. in which the presence of BIM education in the country was explored. Lastly, an updated version of the conceptual framework is presented as it appears in the comprehensive framework of the Ph.D. research. Discussion on the subject and conclusions and recommendations are subsequently provided.

METHODOLOGY

The Ph.D. research adopted a qualitative approach primarily due to the paucity of research on BIM implementation in the Dominican Republic construction industry. Semi-structured interviews were the method selected for the data collection, while content analysis was method selected for the data analysis. The research was carried out in two phases: preliminary study and main study (Refer to Figure 1). In the preliminary study, two type of interviews were conducted: The first type of interview was directed to Dominican construction organisations, whereas the second intended to assess BIM projects developed in the Dominican Republic by Dominican construction organisations. The preliminary study allowed the researcher to evaluate the effectiveness of the adopted methods and make appropriate changes where needed. For the main study, the research continued carrying out the interviews directed to construction organisations with a more refined interview guide. Nonetheless, the interviews to evaluate BIM projects were discarded. Instead, another type of interview was designed and conducted in the main study, which intended to attain a new research objective that emerged in the preliminary study "To explore and document the presence of BIM Education in the country". This second type of interview was directed to professionals of the industry involved in any form of BIM education/training in the country. Key findings on this subject will be briefly presented in this study.

Furthermore, as part of the literature review process, a thorough investigation on BIM education was conducted. Literature findings presented the development of a framework for BIM Education as an excellent strategy to overcome the lack of BIM Education in the country. An initial conceptual framework was developed based on the literature review on BIM Education and the analysis of several BIM education frameworks (Silverio et al., 2017a). This framework was then modified into a simpler version and was incorporated into the comprehensive framework to facilitate the implementation of BIM in the D.R. Such framework is composed of three frameworks directed to the key players that can propel the implementation of BIM in the D.R.: Academia, Construction organisations and the Central government/Public sector. The framework directed to Academia will be discussed in this study.

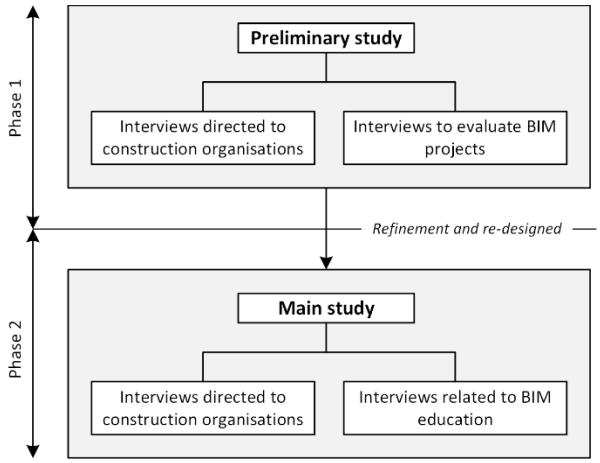

Figure 1 Phases of the research: preliminary study and main study

BIM IN HIGHER EDUCATION

BIM education can be defined as "*a continuous learning process that covers the knowledge required for individuals to be capable of being part and understand what a BIM process is. Such learning process needs to include the essential aspects of BIM implementation, the performance of the participants and the technical skills individuals need to acquire depending on the discipline they belong to and their role in the construction team"* (Silverio et al., 2016; 2017a). There are several stakeholders involved in the delivery of BIM education: Academia, construction firms, software companies, BIM training centres, professional associations, BIM learners, etc. (AIA-CA, 2012; CIC, 2013; Rooney, 2019). Academia is par excellence the main provider of BIM education; whereas the rest provide BIM training, which is a complementary part of BIM education (Silverio et al., 2017a).

It is widely believed that the primary education required to overcome the lack of BIM skilled needs to be cultivated in higher education institutions (Miller, Sharma, Donald, & Amor, 2013; mHardin & McCool, 2015). Efforts to integrate BIM in educational institutions are new to a certain extent (Abbas et al., 2016). Many higher education institutions around the world are incorporating BIM Education in their AEC programmes in undergraduate and postgraduate level. USA, Chile, Finland, Sweden, Netherlands, UK, Singapore and Australia are creating many courses and subjects. Also, vocational institutions are delivering BIM education to the professionals of the industry (Rooney, 2019).

Nonetheless, many institutions have been criticised for their poor approaches and because the quality of many academic programmes have not met the industry and students expectations (Wu & Issa, 2013). The high demand for BIM skilled professionals, and other aspects of BIM such as the increasing implementation of BIM, its constant evolution of BIM and the fast development of BIM processes and technologies and present challenges to develop and plan BIM educational programmes (Suwal & Singh, 2018). AEC educational institutions need to take advantage of the opportunities BIM offer and overcome the challenges related to BIM to stay important and up-to-date (Bozoglu, 2016).

Challenges of integrating BIM in Academia

Research has documented numerous challenges that hinder the integration of BIM in Academia. Table 1 presents a summary of these challenges, categorised in the following categories: Academic aspects, Cultural resistance, Challenges intrinsic to BIM, and Incompetent student's knowledge.

Table 1. Challenges of integrating BIM in Academia

Academic aspects	
Curricula development	- Lack of space in the curriculum to introduce new courses (Sabongi, 2009) and uncertainty on how to adapt new subjects into an already full curriculum (Macdonald, 2012); - Confusion if BIM should either be included in current curricula of AEC disciplines or be provided as a particular subject on its own (Miller, Sharma, Donald, & Amor, 2013); - The restricted number of BIM programs (required or optional) that students can take before they graduate (Sabongi, 2009); - The insertion of BIM is ussualy carried out in simple, intensive and isolated courses (Lee & Hollar, 2013; Magiera, 2013) - Being able to balance theory and practice; technology and process and traditional and new methods (Puolitaival & Forsythe, 2016). - Lack of support from faculty administrators and colleagues to modify the curriculum (Sabongi, 2009; Becerik-Gerber, Gerber, & Ku, 2011)
Accreditation	- How the insertion of BIM can affect the accreditation status of the curriculum (Kocaturk & Kiviniemi, 2013; Suwal, Jäväjä, Rahman, & Gonzalez, 2013); - In terms of accreditation, there are different stadards for graduates from different areas in relation to interdisciplinary collaboration skills (Witt & Kähkönen, 2019)
Preparation	- Incapacity to connect the traditional silos that are present in the architecture, engineering and construction schools, where there is minimim to none collaboration between disciplines (Macdonald, 2012). - Lack of knowledge and experience of academics in BIM (Becerik-Gerber et al., 2011; Gardner et al., 2014; Kugbeadjor, Suresh, & Renukappa, 2015; Puolitaival & Forsythe, 2016; Rooney, 2019). - Enable professional development for academics (Puolitaival & Forsythe, 2016). - Academics need to become skilled and stay up-to-date with current BIM software (Puolitaival & Forsythe, 2016; Witt & Kähkönen, 2019) and processes as BIM is constantly evolving (Puolitaival & Forsythe, 2016). - How the current personnel will adapt to the new skills and understanding demanded by BIM (Kocaturk & Kiviniemi 2013); - Time to prepare BIM-related educational programmes (Becerik-Gerber et al., 2011; Puolitaival & Forsythe, 2016; Witt & Kähkönen, 2019) - Time to prepare faculty staff to get used to BIM software (Witt & Kähkönen, 2019) - Incertitude of what to teach since BIM is continuously evolving (Witt & Kähkönen, 2019) - Organise and motivate multi-diciplinary collaboration among students and faculties. (Witt & Kähkönen, 2019) - Universities usually are under-resourced in regard to providing the required technical support for BIM-related educational strategies (Puolitaival & Forsythe, 2016; Witt & Kähkönen, 2019)
Teaching resources	- Availability of suitable teaching and learning resources (Puolitaival & Forsythe, 2016). - Shortage of books and other training materials (Sabongi, 2009; Becerik-Gerber et al., 2011; Magiera 2013; Gardner, Hosseini, Rameezdeen, & Chileshe, 2014;); however, Puolitaival & Forsythe (2016) pointed out that recently this challenge has turned into finding proper material among the large amount of material available. - Lack of proper BIM models to be used in BIM Courses (Puolitaival & Forsythe, 2016).

	- Classrooms may not be properly designed and equipped to undertake collaborative work (Witt & Kähkönen, 2019).
Investment	- BIM demands the use of state of the art IT equipment and high-priced software, and it can be difficult for universities to get the correct IT environment (Hogle, 2013; Magiera, 2013); - Similar to what happens in the industry, there is mistrust among the professionals in Academia and questions such as "who is responsible for" and "who will pay for" multidisciplinary courses can arise (Macdonald, 2012).
Cultural resistance	
From Academia	- Several academics still see BIM as a CAD software that students should learn by themselves in their own time (Becerik-Gerber, Jazizadeh, Li, & Calis, 2011); - Resistance to change traditional teaching methods which have been implemented over many years to incorporate BIM (Sabongi, 2009; Macdonald, 2012); - Objection to modify the curriculum to include BIM since there is the possibility that other technologies replace BIM in a few years (Sabongi, 2009); - Reluctance from experienced people to adopt a new concept where they are not experienced or be trained again in a field they are not familiar with (Macdonald, 2012); - Uncertainty if creative artistic expression can be achieved within a collaborative practice; - Incertitude if professionals can preserve and defend their values in this innovative, cooperative and democratic pluralism (Kocaturk & Kiviniemi, 2013)
From students	- Lack of interest or reluctance from students to scrutinise the new technology (Sabongi, 2009); - Students' perception that the workload of BIM-related education is bigger than conventional curricula (Witt & Kähkönen, 2019)
Challenges intrinsic to BIM	
Teaching aspects	- BIM Programmes focus mostly on software skills (Lee & Hollar, 2013;Rooney, 2019); - BIM treated as a design tool only (Wong, Wong, & Nadeem, 2011); - BIM needs a determined knowledge of business practice and workflow which is hard to simulate in a teaching course (Magiera, 2013); - It is challenging to assess students in a BIM-enabled education as it is hard to fully and equally motivate students to do collaborative work (Witt & Kähkönen, 2019); - The use of real projects can be overwhelming for the students due to their technical complexity (Witt & Kähkönen, 2019); - BIM skills vary significantly between indivuals students from the same area and between students from different areas (Witt & Kähkönen, 2019).
Technology aspects	- Technologies typical of a BIM process tend to evolve very quickly, and academics that have been kept out of the industry for some time may feel overwhelmed when attempting to keep updated (Macdonald, 2012); - Incertitude of which BIM platform (e.g., Revit, Bentley, etc.) will become predominant (Sabongi, 2009); - Interoperability issues which can occur between different software packages and between different versions of the same software (Witt & Kähkönen, 2019).
Limited student's knowledge	
Construction knowledge	- The discipline-specific knowledge and understanding of construction systems and processes of undergraduate students is still limited to learn BIM (Puolitaival & Forsythe, 2016)

	- Improper model development due to lack of knowledge of construction sequence (Puolitaival & Forsythe, 2016).

Enhancing the integration of BIM in higher education

Faced with these challenges, researchers and BIM educationalist have proposed several strategies to overcome these challenges and improve the way in which BIM education is currently delivered in higher education:

- Full programs should be reevaluated and reformulated concentrating on the changes that BIM implies;
- Almost all the AEC disciplines need to change their current curricula in order to integrate BIM as one of the main subjects;
- International accreditation or, alternatively, national accreditation should be sought in order to incentive academic institutions to introduce BIM in their curricula (Suwal et al., 2013); and improve uniformity in university curricula (Badrinath, Chang, & Hsieh, 2016).
- A common framework should be develop to specify the requirements of which BIM topics could or should be integrated into university curricula and how (Suwal, Jäväjä, Rahman, & Gonzalez, 2013); This academic framework should be informed by BIM research, BIM professionals and other members of the industry (Bozoglu, 2016).
- Core curriculum development (Puolitaival & Forsythe, 2016), which aims to properly define the core content of the curriculum and focus in fundamental aspects of a subject (Karjalainen, Alha, & Jutila, 2006).
- BIM education should be integrated at the program level rather than in an isolated course (Pikas, Sacks, & Hazzan, 2013).
- BIM education should pay attention to both, managerial and technical skills, in the curricula development (Jin et al., 2019).
- A complete education programme or curriculum that encompasses different elements of BIM would be necessary for students from several disciplines (Jin et al., 2019).
- Higher education institutions need to provide collaborative learning spaces to allow multidisciplinary/collaborative teamworking and equipped with ICT and BIM tools (Shelbourn, Macdonald, McCuen, & Lee, 2017).
- Integration of integrate practical implementation of subjects and problems reported in real situations (Kumar, 2015);
- Project based teamwork approaches can be integrated in BIM courses in order to reduce the differences in the perception towards BIM between students and professionals in the industry (Zou, Xu, Jin, Painting, & Li, 2019).
- Active research on BIM curriculum development processes and emerging BIM trends worldwide to respond to industry's needs (Puolitaival & Forsythe, 2016) and prepare BIM-ready graduates worldwide (Badrinath et al., 2016).
- Diffusion of BIM through wrokshops and short courses directed to the AEC community outside academia (Badrinath et al., 2016).
- Establish multidisciplinary schools and BIM educational institutions supported by the government and the industry to enable BIM learning across industry and academia (Badrinath et al., 2016).
- Self-training along with constant peer support and bespoke workshops as a cost-effective option to enable professional development of academic staff (Puolitaival & Forsythe, 2016). Academics also need to receive training on new software technology (Badrinath et al., 2016).
- Inclusion of collaboration requirements and BIM technical skills within the new/modified BIM curricula to enhance the abilities of graduates from different disciplines of the industry (Gardner et al., 2014). Collaborative practices with other disciplines allows students to understand different

roles in the industry and their implications in a projects. This can be achieved through collaborative teaching and activities such as student competitions (Shelbourn, Macdonald, McCuen, & Lee, 2017).

- Students should collaborate in the process of creating a BIM programme and developing a BIM curriculum (Wong, Wong, & Nadeem, 2011). For instance, the perception towards BIM from students is very important in the development of BIM Education. Academics can assess their pedagogical work through students' feedback and make appropriate changes if necessary (Jin, Zou, Li, Piroozfar, & Painting, 2019).
- Motivate and advise students to look for resources on their own in respose to in order to solve the issue of selecting appropriate learning materials for BIM due to the excess of material and fast-changing nature of this topic (Puolitaival & Forsythe, 2016).
- To solve the problem of lack of proper BIM model, Puolitaival & Forsythe (2016) suggested two approaches. First option is the use of models obtained from the industry following industry standards, which can be: (1) models used in real projects (2) models created by contracting model authoring professionals or companies from 2D documentation. Second option is the use of models developed internally by (1) staff from 2D documentation, (2) by students, from both, 2D documentation and their own design projects.

Collaboration between Academia and industry players

Collaboration between Academia and industry players is highly recommended to enhance the benefits of BIM implementation (Lee & Hollar, 2013), overcome the lack of BIM skilled professionals in the industry (AIA-CA, 2012; Hogle, 2013), and keep academics up-to-date (Macdonald & Mills, 2011). Academic staff teaching BIM-related programmes should keep in contact with industry players to integrate and redesign the content of the BIM programmes following industry tendencies and practices (Lee & Hollar, 2013) and bridge the gap between theory and knowledge with the contribution of industry BIM experts (Wu & Issa, 2013).

A closer relationship between Academia and the industry would provide multiple benefits to BIM education. This collaboration would improve higher education institutions and assist industry partners to hire BIM talents (Wu & Issa, 2014); assist in developing a greater perception of BIM education areas (e.g. BIM for lifcycle management) (Jin, et al., 2019); and would allow academics to check industry's needs to manage the balance between theory and practice; technology and process; and traditional and emerging methods (Puolitaival & Forsythe, 2016).

In terms of curriculum development, the specifications of BIM-related careers/courses/modules and the expectations of BIM education learning outcomes can be better defined with the participation of Academia and the industry (Wu & Issa, 2013). BIM teaching material can also be created through the collaboration of academics, industry experts and software developers. An online collaboration platform would be advantageous for this type of initiative (Suwal, Jäväjä, Rahman, & Gonzalez, 2013). Academics and industry players can join through knowledge transfer partnerships in order to create training programs that meet industry demands. Another important benefit of this alliance is the creation of frameworks to integrate BIM in existing curricula and create new BIM curricula (Byrne, 2015).

Students can also be given opportunities to research new concepts and technologies within the field of BIM, a task that the industry on its own struggles to do due to lack of time and resources (Hogle, 2013). Moreover, incentives to attract and motivate students in BIM-oriented career paths can be provided through this alliance. For instance, formal BIM programmes such as internships and coops; interdisciplinary BIM education; intercollegiate BIM education collaboration; and lab facilities (Wu & Issa, 2013). Activities to drive BIM education can also be developed. For instance, direct pedagogic contributions by BIM experts from the industry; knowledge sharing between academics and professionals through conferences or

workshops (Wu & Issa, 2013); site visits; case studies; visting lecturers from the industry (Hogle, 2013) and the participation of industrial speakers (Shelbourn, Macdonald, McCuen, & Lee, 2017).

The presence of industry players add value to BIM teaching practices. For instance, practical learning methods can be integrated into BIM curricula through modules supported by the industry (Byrne, 2015). Industry partners can be part of the BIM courses to complement the skills and knowledge of academics (Puolitaival & Forsythe, 2016) and assess students work (Jin et al., 2019). Industry players can also indicate the significance of learning material allowing students to become betters hires (Hogle, 2013). If academic institutions want to use BIM models of real projects, a close relationship with external property developers interested in the use of BIM can be beneficial to avoid IP issues (Puolitaival & Forsythe, 2016).

BIM Education drivers

This section will discuss the main driver for BIM Education namely Central government and public sector, Academia and AEC industry players. These were identified by studying different initiatives that have driven BIM Education worldwide.

Central government and public sector

The central government and public sector can support the provision of BIM education and training to develop BIM skills in the industry. As per Sanchez, Kraatz, & Hampson (2014), government mandates would give the necessary context for BIM education/training providers (such as higher education and technical institutions) and professional organisations to collaborate in the development of new courses to improve the skills of the professionals of the construction industry. For instance, the UK government created the former BIM Task Group to lead the BIM mandate in the country (HM Government, 2013) which set different approaches to provide resources, education, and training to the government and the industry (McGraw-Hill Construction, 2014). In 2011 they created the BIM Academic Forum, a group of representatives from several UK universities that aims to support the educational aspects of BIM. This group focused mainly on the creation of a BIM academic framework: Learning Outcomes Framework (LOF) (Underwood, Khosrowshahi, Pittard, Greenwood, & Platts, 2013).

This latter constitutes another approach to support the delivery of education/training: the creation of training methods to guide organisations on how to create BIM education/training courses (Cheng & Lu, 2015). An example of this approach includes the aforementioned Learning Outcomes Framework and the training framework developed by the Building Construction Authority (BCA) Academy in Singapore to ensure that all the stakeholders in the industry receive BIM knowledge (BCA, 2011). The central government and public sector can also act as educators if they have qualified personnel for this purpose. For instance, the Hong Kong Construction Industry Council (CIC) delivers BIM courses to a wide range of professionals. They also work with training institutions to increase BIM competencies throughout the industry and with industry players to organise BIM promotional activities (Rooney, 2017). In January 2018, Plan BIM in Chile, the 10-year programme that proposes the implementation of BIM by 2020 (PlanBIM, 2018), created the *Seminario Internacional de Formacion de Capital Humano en BIM* (International Seminar on BIM Human Capital, in English) in which was introduced the Matrix of BIM Roles, a document that guides academic institutions regarding the different skills that professionals need to cultivate (Rooney, 2019).

Academia

Many higher education institutions around the world have gotten involved in providing BIM Education either driven by a BIM mandate or by own initiative (Silverio, 2019). For instance, in the USA by 2019, there were 68 public and 39 private universities providing formal Architecture and Engineering

Programmes in the USA (Rooney, 2019). Academic institutions in late adopters BIM countries are also catching up with BIM leader countries. In Chile, the numbers of higher education institutions delivering BIM education programmes is growing significantly. In 2018, Fernandez Gonzalez (2018) reported that 41% of universities in Chile where delivering BM knowledge mainly in Architecture. Later, Rooney (2019) reported that by 2019 there were 42 universities in Chile delivering BIM training, which represents an increase of 81% throughout the country. 84% of the 106 programmes delivered in 2018 have integrated BIM in compulsory courses on their curricula.

Industry

The industry can contribute to the provision of BIM Education through the participation of different players: BIM training centres, software developers, professional bodies/industry associations and even construction organisations.

BIM Training centres and registered training organisations are important providers of BIM training within the industry. They offer services to the industry in general as well as customised services to construction organisations (AIA-CA, 2012). Moreover, software developers provide BIM training for their software solutions which can be included the software package or have an additional fee (CIC, 2013; Rooney, 2017). Professionals bodies and industry associations can play an important role in promoting BIM in Academia (AIA-CA, 2012). There are important organisations of this type providing BIM training to the industry. For instance, the Associated General Contractors of America AGC in collaboration with leading BIM users, technology companies and academics, created a BIM Education Program to prepare professionals at all levels. Once participants complete the programme, they can take an exam to get the Certificate of Management-Building Information Modelling (CM-BIM) (Rooney, 2019). As indicated by Bozoglu (2016), professional bodies advocate BIM professionals and create interesting job positions; therefore, another important role for them is to guarantee that BIM is a career option for those who are skilled in the subject. Professional bodies also accredit degree courses delivered by higher education institutions and monitor that they are meeting their mandatory published standards.

BIM-centred professional organisations are organisations created solely to drive, promote and support the industry with respect to BIM. Their main role is to create networks as they can involve different stakeholders from the government, the industry and academic (Silverio, 2019). In terms of BIM Education, these organisations have made significant contributions worldwide. For instance, the Hong Kong Institute of Building Information Modelling (HKIBIM) has provided guidance on the creation of BIM careers and BIM training (HKIBIM, 2018).

Construction organisations can also get involved in the delivery of BIM training. Driven by market demands, construction organisations are heavily investing to upskill their staff by providing training through either external training providers or in-house training (AIA-CA, 2012; CIC, 2013).

BIM Education frameworks for Academia

The need for frameworks to facilitate the integration of collaborative design and BIM education in higher education institutions has been posited before by academics (Macdonald & Granroth, 2013; Macdonald, 2012; Macdonald & Mills, 2011). To create the initial framework, which was conceived under title “BIM Education framework for clients and professionals of the construction industry”, several BIM Education frameworks directed to Academia and the Industry were gathered and analysed. Only frameworks that were developed to guide the delivery of BIM education in general, not for specific disciplines/courses, were considered (Silverio et al., 2017a). Table 2 presents the frameworks analysed in this study. From them, the Learning Outcomes Framework (LOF) is the only one is based on a BIM mandate; the rest were developed from initiatives from Academia and industry players.

Table 2. Existing frameworks to assist the integration of BIM in Academia (Silverio et al., 2017a)

Framework	Sections	Points covered	Actors involved
IMAC framework (Australia) Code BIM Project: Australian Office of Learning and Teaching (OLT) along with the University of Technology Sydney, University of South Australia and University of Newcastle *(MacDonald, 2012; Macdonald and Mills, 2011; Macdonald & Granroth, 2013)*	Stages of the framework: • Illustration • Manipulation • Application • Collaboration	Provides a benchmarking tool and a guide to assist academics in the insertion of collaborative design education and BIM in AEC curricula.	Providers: Academia Beneficiated: Students (levels not specified)
New Zealand's national draft framework: The University of Auckland *(Miller, Sharma, Donald, & Amor, 2013).*	Includes the three types of education that the study considers necessary in a BIM educational framework: - Vocational training and continuing professional development; - Degree Programmes (Undergraduate and Masters); - Research (including PhDs). The requirements of each type of education are explained in three domains encompassed in the implementation of BIM: Architecture, Engineering, and Construction; Software and Technologies; Business, Enterprise, and Management.	Specifications of learning outcomes demanded by Vocational Training/Continuing Professional Development (CPD) in the three domains; Proposes the insertion of BIM in existing bachelor's degree's curricula Proposes the creation of Integrated BIM masters; Considers to carry out research in further areas than the ones presented in the framework.	Providers: Academia CPD providers Beneficiated: Current practitioners Undergraduate, masters, and research students
Collaborative BIM education	Components:	Identification of BIM competencies;	Providers: Academia

framework from the BIM Education Working Group (EWG) (Australia) *(AIA-CA, 2012; Succar & Sher, 2014)*	A: Identifying BIM Competencies B: Classifying BIM Competencies C: Arranging competencies and designing BIM learning modules D: An industry framework for professional development E: An academic framework for BIM Education F: The BIM Institute	Creation of an online BIM learning hub; Creation of BIM learning modules; Creation of BIM learning materials; Creation of an Industry framework for professional development in the industry; Expansion of existing and creation of innovative CPD programmes Creation of an Academic framework; Expansion of existing and creation accredited programmes. Creation of a BIM institute.	Industry Other BIM education providers Beneficiated: Students (levels not specified) Current practitioners
Learning Outcomes framework (UK) **BIM TASK GROUP and BAF** (BIM Level 2, 2016; BIM Task Group, 2012; Underwood et al., 2015)	Categories of the initial framework: Strategic; Management; Technical. Categories of the final version: Understand the essence BIM, BIM Level 2 requirements established and its relationship with the Government Construction strategy 2025; Understand the implications and value of BIM in the organisation; Understand the requirements for information management and exchange described in the 1192 suite of standards PAS55 / ISO 55000.	Provides the learning outcomes (LOF) needed to successfully implement BIM level 2. It can be applied in both the industry and Academia. For the implementation in Academia, the LOFs are specified for undergraduate levels (4, 5 and 6) and post-graduate level (7).	Providers: Academia Industry Beneficiated: Current practitioners Undergraduate and post-graduate students

The development of this initial framework (Refer to Appendix 1) was informed by the IMAC, the New Zealand's National Draft and the Collaborative BIM education framework from the BIM Education Working Group (EWG) since they are not created based on a BIM mandate, which is the current context of the Dominican Republic in terms of BIM.

BIM Education in the Dominican Republic

Silverio et al. (2017a) reported that the topic of BIM Education emerged in the preliminary study of the Ph.D. research "Implementation of Building Information Modelling in the Dominican Republic construction industry" and that further data collection was designed in the main study to investigate the

presence of BIM education in the country. The following sections will briefly describe the investigation process undertaken as well as the key findings of the investigation.

Investigation process

The first indications of BIM education in the D.R. were identified in the preliminary study of the Ph.D. research: a training centre (Training Centre A) that provides a type of "BIM seminar" in the last phase of a software training course in Vectorworks and the a university interested in integrating BIM into the Civil Engineering curriculum (University B). To recruit potential candidates to investigate the presence of BIM education in the D.R., an online search was carried out. Keywords related to BIM Education and Training were used (in Spanish). Two Diploma courses, a BIM conference, courses on BIM software for Architecture Design, and an Architect committed to the diffusion of BIM knowledge were identified (Refer to Table 3). Moreover, keywords were also used in the websites of universities offering careers that belong to the construction industry were search and the professional networking platform LinkedIn. Nonetheless, there were no new results.

Table 3. Results of the online search for BIM Education

Keyword combination	Results
BIM + Educacion + Republica + Dominicana	BIM Diploma course and BIM informative talk in *University A*
	A conference dedicated to BIM and IPD in *University B*
BIM + Diplomado + Republica + Dominicana	BIM Diploma course in *University B*
	Three Revit courses and one ArchiCAD course
BIM + Cursos + Republica + Dominicana	Webpage of an Architect dedicated to the dissemination of BIM knowledge
BIM + Universidad + Republica + Dominicana; BIM + Formacion + Republica + Dominicana	No results

A lecturer from University A (Interviewee C) and the aforementioned architect (Interviewee G) could be contacted through the online search. Also, a representative (Interviewee E) of a Professional Body (Professional Body A) took part of this research because it was identified that the institution hosted a BIM talk conducted by Interviewee G, whose video is available online. The rest of the participants were identified through the researcher's networking (Interviewee E) and through the snowball sampling strategy. In total, 9 people participated in the investigation of the presence of BIM Education in the D.R. Refer to Table 4 to see the profile of the participants.

Table 4. Profile of the participants of the study of BIM Education in the country

Int.	Profile
A	Civil Engineer and MSc in BIM.
B	Non-graduate. He was a student of Architecture.
C	Civil Engineer. Professor and Researcher at *University A.*
D	Architect. Founder member of *Training Centre C*.
E	Architect. Director of the Continuing Education Department of the Headquarters of *Professional Body A*.
F	Architect. Professor at *University C*, CEO of *Training Centre A,* and exclusive Vectorworks provider
G	Freelance Architect.
H	Civil Engineer. Professor at *University A.*
I	Architect.

Findings

The key findings of the investigation of the presence of BIM education in the D.R. include are (1) Shortage of BIM experts, (2) Lack of BIM education: Presence of training, (3) Dissemination of BIM knowledge, and (4) Plans on BIM education and training (Silverio et al., 2017b).

Shortage of BIM experts

(Gardner et al., 2014) indicated that there is a small group of academics committed to disseminating BIM knowledge across the industry because BIM is still novel, and its implementation is still progressing. Hence, it was expected to find the same scenario in the D.R., where BIM is new, and its implementation is limited. This shortage of BIM experts was first detected in the recruitment of participants. Moreover, from the participants, only six of them can be considered BIM experts. Interviewees C, D, and E do not deliver any BIM knowledge themselves; they are just advocating its dissemination (Refer to Table 5).

Table 5. Academic background of the participants and the BIM training/knowledge they deliver

Int.	Academic background on BIM	Modes of delivering BIM knowledge and training
19/A*	BIM Diploma course at University A MSc in BIM in the UK	Coordination of the BIM Diploma course in University A; Talks.
B	No education. An autodidact with books and the internet.	Talks; Revit courses oriented to BIM; Revit in-house training and BIM champion of the company he works for.
C	BIM Diploma course in University A. Does not teach about BIM; he is just a supporter.	Coordination of the BIM Diploma course and talks in University A; Coordination of the insertion of two BIM modules in the Civil Engineering curriculum of University A.
D	No education. Just software courses in Revit. Does not teach about BIM; he is just a supporter.	Development of conferences where BIM talks and panels have been included; Coordination of Revit courses oriented to BIM.
E	No education. Does not teach about BIM; he is just a supporter.	Host talks; Interest in delivering courses on BIM.
F	No education. An autodidact with books and the internet.	Talks; Vectorworks courses oriented to BIM; Software consultancy to companies.
G	No education. An autodidact with the internet.	Revit courses oriented to BIM; BIM Diploma courses; Revit in-house training and BIM implementation strategies consultancy to companies; Talks.
45/H and 46/I*	BIM Diploma course at University A.	Coordination of the BIM Diploma course in University A; BIM Diploma courses; Participation and organisation of talks, conferences and forums in University A and Training Centre D; Training and consultancy to companies; Revit training courses oriented to BIM.

*This naming convention was used for all the interviewees of the Ph.D. research

Lack of BIM Education: Presence of training only

Thus far, BIM Education is not provided in Dominican higher education institutions. There is only BIM training focused on software skills, which is delivered as software courses and diploma courses. As confirmed by Interviewees G, H, I, construction organisations are starting to demand in-house training and consultancies in order to implement BIM. Also, BIM knowledge is being currently diffused through educational activities and a BIM informative forum.
The lack of BIM Education in the country is also evident through the profile of the BIM education stakeholders that participated in this study. As shown in Table _, many of them are autodidacts in the area of BIM. Only interviewees A, C, 45/H and 46/I took a Diploma course in the country that is not delivered permanently. Interviewee 19/A did a master's degree in BIM in the UK.

- **Software courses.**

Software courses are the most popular mode of BIM training in the country. Most of them do not focus on BIM. Their descriptions/content usually emphasise that they merely teach the software. This issue was identified by several interviewees (19/A, B, G, 45/H and 46/I) who pointed out their limited focus on BIM and their poor teaching approaches: *"That's the other issue, that the courses delivered in this country are normally focused on software and the trainers, I won't say all of them, but some of them are software providers, and they restrict themselves to teach you the software. They do not give you the vision of implementing BIM in a project"* – Interviewee 19/A.

- **Diploma courses**

Diploma courses were the most formal mode of BIM training identified. These courses are not delivered regularly and usually focused on software skills. By the time of the investigation, only two Diploma courses had been delivered in 2013: one in University A and one in University B (Refer to Table 3). The diploma course of University A was coordinated by academic staff and delivered by educators from Brigham University (USA), as a result of an agreement between both universities. Interviewee C indicated that the course primarily included an introduction to BIM and modelling lessons in the software Revit and Navisworks. On the other hand, the diploma course of University B was delivered by a BIM stakeholder, not an academic staff from the university. The course included knowledge on IPD and BIM processes, use of Revit and Navisworks and the development of a BIM project (UNIBE, 2013). Information about this diploma course was obtained through the internet since the facilitator of the course could not be contacted for this study.

During and after the main study was conducted, other diploma courses were identified. Interviewee G indicated to have prepared a diploma course to teach BIM and the software Revit. The course was planned to start being delivered since January 2017 in two universities in the capital and North of the country (University C and D). After the first delivery, the course has been delivered continuously on both universities. Moreover, Interviewees 45/H and 46/I got involved in the delivery of one Diploma course in Training Centre D. The course encompassed three modules: Introduction to BIM, Project's coordination with BIM and Implementation of BIM. Skills on the software Revit were indicated as entry requirement. In September 2019, University B took the initiative of developing a Diploma course with academic staff directed to Architecture students and architects, under the name "Diploma course of Innovation in Architecture". In the description is specified that the students will be introduced to Design through programming, IPD and digital fabrication (UNIBE, 2019).

- **In-house training and BIM consultancy to companies**

Several interviewees stated to have provided this type of services to construction organisations. Interviewee B introduced the implementation of BIM in the construction organisation he works for. Interviewee E has provided software consultancy to several organisations through Training Centre A.

Interviewee G has introduced BIM to several organisations and provided in-house training in the software Revit. Interviewees 45/H and 46/I have provided consultancies in BIM implementation strategies and in-house training in the software Revit and Navisworks.

Dissemination of BIM knowledge

Educational events such as talks, conferences and forums about BIM were identified. These activities have been mostly held universities across the country, followed by professional bodies and training centres. As presented in Table 5, all the interviewees have participated in this type of activities either as organisers or facilitators. The porpularity of these activities is increasing lately.

In December 2016 five professionals of the construction industry along with the researcher gathered to create the first informative BIM forum of the country called ProBIM. The forum started to disseminate information about BIM through "quick read" articles in their initial web page. Nowadays, the forum is just present in social media platforms: Instagram (user: @ProBIM_ORG), LinkedIn and YouTube (user: ProBIM), from which Instagram is the most important channel. Short articles are written and published through Instagram about different topics: general BIM knowledge, emerging tendencies, case studies of BIM projects, etc. Also, live videos are broadcasted to cover specific topics and interact with the followers. Both, the publications and videos are shared in the other platforms (ProBIM, 2016; ProBIM, 2017b; ProBIM, 2019a). The forum has contributed significantly to the diffusion of BIM knowledge among professionals of the industry. It has grown in terms of members and scope. In the last two years, it has hosted important educational activities in different universities and in Professional Body A to raise BIM awareness in the industry. They have also delivered one-day workshops in specific areas such as "Modelling from Point cloud data". The forum has stated their commitment of driving the OpenBIM approach in the Dominican construction industry. For instance, the topic of their latest event "2da Jornada OPEN BIM" (2nd OPEN BIM Conference, in English) was around this topic (ProBIM, 2019b).

Professional Body A has also expressed their interest in delivering BIM knowledge to the industry. Interviewee E stated that the institution is interested in delivering BIM courses. There was already an attempt of planning a BIM Diploma course that failed due to lack of BIM experts (Silverio, A.K., Suresh, S., Suresh S. and Heesom, D., 2017). In terms of activities, Interviewees confirmed that Professional Body A has hosted educational activities related to BIM: an introductory BIM talk delivered by Interviewee G, seminars held by Interviewee 45/H and 46/I. They have also collaborated with ProBIM in educational activities since August 2017 (ProBIM, 2017a).

Plans on BIM Education and training

Interviewees were asked about their plans concerning the delivery of BIM knowledge and BIM education and training. The most interesting plan presented by the interviewees was the plan of one university to integrate BIM within a career's curriculum. As per interviewees 19/A and C, there was a curriculum reform in the career of Civil Engineering in University A which will take effect for students enrolled from August 2016 onwards. The modifications include the improvement of one module and the insertion of a new module, both to be delivered in the last year of this career, which is three-year long. Therefore, the new curriculum will be effective from 2019. The modified module is called "Technical drawing for Civil Engineering" and students will be taught the software Revit instead of AutoCAD. On the other hand, the new module is called "Computer Aided Design" which is planned to be delivered by Interviewee 19/A. Interviewee 19/A gave some details about the module, including the intentions of teaching students the software Navisworks. The aim of both modules is that students acquire the necessary skills to use models for different tasks such as Design analysis, Clash detections, Cost Estimations, construction schedules, construction simulations, etc. The strategy implemented by this university is defined by Suwal & Singh (2018) as Individual BIM, in which a stand-alone course is provided as part of CAD courses or as substitute of existing CAD courses.

Updated BIM Education framework

Silverio et al. (2017a) developed a BIM Education framework directed to students, current practitioners, and clients. Such framework was developed to be incorporated into the framework (formerly toolkit) to facilitate the implementation of BIM in the D.R. The framework is a comprehensive framework which is formed by three frameworks directed to the key players that can propel the implementation of BIM in the D.R.: Academia, construction organisations and the Central government/public sector.

To incorporate the initial BIM Education framework to the comprehensive framework, outcome of the Ph.D. research, several changes were carried out. First, the framework was split into two. The part covering Academia constitute only one framework; whereas the part including the industry was incorporated into the framework directed to construction organisations. Also, the initial framework was divided into three stages: Strategy, Implementation and Revision Stage. On the other hand, the updated framework directed only to Academia, comprehends four stages: Strategy, Preparations, Realisations and Revision. Finally, to facilitate its understanding, the updated framework was simplified graphically (Refer to Figure 2).

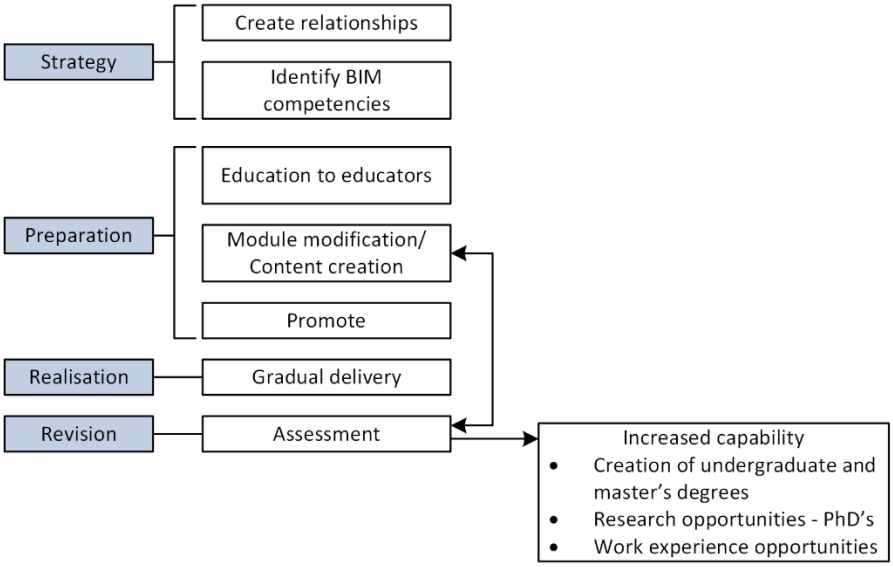

Figure 2 Updated framework: Framework to guide the integration of BIM into university curricula

Stage 1: Strategy. The first stage consists of the development of the strategies to be followed. For that, it is necessary to establish a lead. The best option for this is to establish formal relationships between academics and industry players interested in the integration and improvement of current approaches to BIM Education. In the D.R., industry players that can be part of this process comprehend professional bodies, BIM training centres, BIM training stakeholders, BIM adopters (professionals and construction organisations), and BIM informative forums. Support from the government is desirable, but in the context of the D.R., this is not attainable yet because the government has not gotten involved with BIM yet. The players taking part in this strategy need to identify the BIM competencies required in disciplines and courses of current curricula. BIM experience from current BIM practitioners represents a great contribution to this matter.

Stage 2: Preparation. Once the competencies are identified, proper education needs to be provided to prospect educators. In the D.R. was observed that most of the stakeholders involved in BIM education and training are autodidact. Even though these players are already contributing significantly to enhancing BIM skills in the country, they require proper preparation before getting involved in Academia. After educators receive the required education, they will be able to modify current modules and prepare the necessary teaching material. This stage can also be done in collaboration with other industry players. While doing all

this process, BIM needs to be promoted through different activities directed not only students but to current practitioners. In the D.R. this is being done mainly to raise BIM awareness but with more participation from the industry than academia itself.

Stage 3: Realisation. This stage consists of the delivery of the modules that have been modified to be aligned with BIM. It is suggested to deliver modules gradually to avoid a massive failure. This gradual integration can be organised by disciplines. For instance, modify the Architecture curricula first and the move to the remainder disciplines. It can also start with senior year students who are more experienced and then work with lower levels.

Stage 4: Revision. This stage consists of the assessment of the first module(s) delivered. This assessment needs to be performed by different players. Firstly, it is important to get feedback from the BIM learners as to the module(s) programme, learning materials provided and learning attained. Furthermore, educators need to supervise the delivery of the modules thus at the end they will be able to evaluate different aspects such as progress and performance of the students; the need for extra training/education for them; and successfulness of the module programme. In this stage, input from industry players is recommended to guide educators as to which improvements may be necessary after assessment has been carried out.
After the first attempt of integration is revised, the process can start again until attaining the final milestone. Then, the lead group will have the necessary capability to take further steps such as:

- Creation of BIM-based undergraduate and master's degrees.
- Research opportunities – PhD's.
- Offer work experience opportunities to BIM learners: internships, coops, etc**.**

The comprehensive framework was validated through member checking (Creswell and Poth, 2017) with the participation of 14 of the participants of the PhD. research. Overall, the framework received very positive feedback in terms of its suitability for the D.R.: *"Yes, it is not only for the Dominican Republic but for any country that establishes the implementation of BIM as a goal in all its domains, from education to governmental mandates"*- Interviewee B.

SOLUTIONS AND RECOMMENDATIONS

This study has presented the importance of the provision of BIM Education in Academia but also the numerous challenges hindering higher education institutions to teach BIM. Many academics and educationalist around the world have worked to overcome these challenges and offer the required education to prepare the AEC labour force to implement BIM successfully. In countries like the D.R., where BIM is at its infancy the challenges can be more difficult to overcome. Thus far, the country is interested in BIM education but is suffering from lack of BIM education. Covering this lack represents a difficult task since the country also has a shortage of BIM experts. BIM training is being mainly delivered by AEC professionals and alliances with Academia have taken place for this purpose, which is the best approach as suggested by the literature. The Dominican government has not expressed its interest of implementing BIM yet; therefore, they are not contributing to the delivery of BIM Education yet.
The framework to integrate BIM into university curricula has been developed to guide interested higher education institutions in the D.R. in the stages they need to go through to plan curricula development. The only approach of inserting, rather than integrating, BIM in university curricula in the D.R. is through an Individual BIM approach (Suwal & Singh, 2018) in two modules of the last year of the Civil Engineering career of University A. Both modules have a strong focus on software. This approach of inserting BIM in Academia through teaching specific software has been identified even in BIM leader countries (Rooney, 2017). Nonetheless, it has been reported that training in OpenBIM concepts and other topics such as collaborative BIM environments, BIM management, Sustainable BIM, BIM for FM and Life Cycle Costing seems to be growing in countries such Australia, Canada, Finland, Hong Kong, Japan, Norway, Singapore,

Sweden, Switzerland and UK (Rooney, 2019). This infers that introducing BIM through software should not be seen as a wrong approach, but as a starting point in the D.R. to get to more BIM-related processes areas, which are the core knowledge needed for successful BIM implementation. It is important to assess the successfulness of this approach and wait to see the of integrating BIM from other universities in order to give recommendations as to how the delivery of BIM Education can be improved.

FUTURE RESEARCH DIRECTIONS

The comprehensive framework, in which the framework directed to Academia to guide the integration of BIM in university curricula has been validated by the participants. There is breadth to test the practical implementation of this framework with the Dominican universities interested in integrating BIM in their courses. Furthermore, since the interest in BIM in Dominican Academia is increasing, further studies could contemplate the analysis of current AEC curricula in the D.R. and identify the best approaches in which BIM can be integrated to existing and new courses. Moreover, an analysis of the demanded BIM roles in the D.R. would also be beneficial to offer guidance as to the content that needs to be delivered in these courses.

CONCLUSION

This study has broadly discussed the subject of BIM Education in Higher Education. Then, the approach of a conceptual BIM Education framework developed in a previous study was introduced. Key Findings from the investigation and the primary data collected in order to explore the presence of BIM education in the country were subsequently presented: Shortage of BIM experts, Lack of BIM education – Presence of BIM training, Dissemination of BIM knowledge in the country and Plans on BIM education and training. Hitherto, only BIM training is delivered in the country with a strong emphasis on software skills, which is mainly driven by professionals of the industry. Many educational events have been organised in the last years, which is contributing to raise awareness in the industry. These events have included the participation of universities, BIM training stakeholders and professional bodies and a BIM informative forum. The first steps of inserting BIM into university curricula have been taken by an important university in the capital of the country. The efforts are in two complementary subjects through an Individual BIM approach that, even though is limited, represent an important initiative in the country in terms of BIM education in the country.

After these discussions, the development of a framework to guide the integration of BIM in Academia was introduced. This framework is an updated version of the previously mentioned conceptual framework which was originally directed to Academia and the Industry. The framework is directed to Academia only and is graphically simpler than the conceptual framework. The framework was modified to incorporate it a comprehensive framework which aims to facilitate the implementation of BIM in the D.R.
The comprehensive framework was validated with participants of the study who confirmed its suitability for the D.R.

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KEY TERMS AND DEFINITIONS

BIM education: It is "*a continuous learning process that covers the knowledge required for individuals to be capable of being part and understand what a BIM process is. Such learning process needs to include the essential aspects of BIM implementation, the performance of the participants and the technical skills individuals need to acquire depending on the discipline they belong to and their role in the construction team"* (Silverio et al., 2016; 2017a).

BIM-centred professional organisations: Organisations that have been created exclusively to drive, promote and give support to the industry with respect to BIM (Silverio, 2019).

Higher education institutions: Institutions that offer degree-level courses.

APPENDIX 1

<table>
<tr><th colspan="4">Academia</th></tr>
<tr><th rowspan="2">Strategy stage</th><th colspan="2">Implementation stage</th><th rowspan="2">Revision stage</th></tr>
<tr><th>Actions</th><th>Participants involved</th></tr>
<tr><td rowspan="6">•Creation of groups with members from Academia and the industry to lead the strategy;
•Identification of the BIM abilities needed per discipline from the educators;
•Identification of the BIM skills per discipline required from the students;
•Categorisation of these abilities by themes, according to the knowledge disciplines of the construction industry.</td><td>Provision of education and training required for the educators.</td><td>•Academics
•BIM education providers
•Industry</td><td rowspan="6">Assessment of the programs created by getting feedback from:
• BIM learners: to express their opinion about program and learning outcomes;
• Academics: by analysing the progress and performance of the students
• Industry: by the evaluation of the BIM learners skills when practical implementation activities are programmed.</td></tr>
<tr><td>Elaboration of the learning modules:
• To be embedded in current programs; and
• For the creation of new programs.</td><td>•Academics
•Industry
•BIM education providers
•BIM learners
•Researchers
•Government (as support)</td></tr>
<tr><td>Creation of BIM learning materials for new modules inserted and programs modified.</td><td>•Academics
•Industry
•BIM providers
•BIM learners
•Researchers</td></tr>
<tr><td>Practical implementation of the knowledge acquired:
• Knowledge transfer partnerships;
• Internships;
• Co-ops.</td><td>•Academics: for planning;
•Industry: to provide opportunities to the BIM learners;
•Government: to promote this practice in BIM education.</td></tr>
<tr><td>Diffusion of other BIM type of education and activities for knowledge boosting and acquisition of transferable skills through workshops, conferences, seminars, etc.</td><td>•Academics
•BIM education providers
•Industry
•Government</td></tr>
<tr><td>Establishment of minimum knowledge requirements to undertake higher education degrees such as masters and research. That is to avoid teaching new things to students that have some gaps in knowledge.</td><td>•Academics
•Industry: to identify problems in practice and propose research in the field.</td></tr>
<tr><th colspan="4">Industry</th></tr>
<tr><th rowspan="2">Strategy stage</th><th colspan="2">Implementation stage</th><th rowspan="2">Revision stage</th></tr>
<tr><th colspan="2">Actions</th><th>Participants involved</th></tr>
<tr><td>•Designation of a BIM Champion to lead the strategy;
•Identification of the BIM scope of the company;
•Identification of the BIM abilities</td><td>BIM Education for the staff</td><td>Higher education: Large funding needed. Suitable for large companies with considerable budget dedicated to training</td><td>Provided by:
• Academia</td><td>•Evaluation of the performance of the staff and the client;
•Comparisons of project outcomes and performances before and after the strategy.</td></tr>
</table>

required per role in the organisation; • Identification of the training to be taken by the staff depending on their role in the team and requirements of the type of projects: - Managerial levels; - Remainder staff; - The client, when needed.		Acquisition/upskill of software abilities:	Provided by: • Software developers; • Expert(s) hired by the organisation; or • Skilled staff from the company designated by the BIM champion.	
		Acquisition of different transferable skills: • CPD programs • Attend to workshops, conferences, seminars, etc.	Provided by: • Organisation; and • BIM education providers	
	BIM education to the client	To receive consultancy in the following areas: - Introduction to BIM; - Establishment of BIM goals for the project; - Documentation management.	BIM consultant from: • The organisation; or • An independent BIM consultant.	