ESTABLISHING A CUSTOMIZED FRAMEWORK OF BIM EDUCATION PROGRAMS FOR OWNERS IN SOUTH KOREA

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ABSTRACT
Building information modelling (BIM) plays an important role in fostering sustainability within the construction industry while facilitating its digital transformation. Through the adoption of BIM technologies, the construction industry can enhance decision-making and communication capabilities throughout the life cycle of construction. Recognizing the evolving landscape of the construction industry, domestic and overseas governments are actively formulating and implementing policies to promote BIM adoption. However, practitioners in public ordering authorities lack sufficient understanding of BIM. Moreover, there is a deficiency in well-established frameworks for the effective utilization and review of final BIM deliverables in BIM procurement processes. In order to address these issues, this paper conducted a comprehensive investigation of BIM-related education curriculums and focus group interviews (FGI) with BIM experts from public ordering authorities. The primary objective is to examine the challenges and considerations associated with BIM education for owners. Based on these, we proposed a public education framework for the development of BIM education curricula that aligns with the current government policies and practices in South Korea as a result. This study is expected to provide a valuable foundation for the development of standardized education curricula tailored to stakeholders in the construction domain, particularly for owners.
Keywords: building information modelling (BIM), public ordering authority, BIM education for owners, framework, focus group interview (FGI).

1 INTRODUCTION

The global construction industry is actively pursuing a transition to a digitalized smart construction system through the integration and convergence of The Fourth Industrial Revolution technologies [1]. This digital transformation encompasses the entire construction process, including design, construction, and maintenance based on building information modelling (BIM). By leveraging this approach, the industry can attain rapid and precise decision-making and communication capabilities while maximizing productivity, safety, and quality through the integration of various technologies such as off-site construction and automated equipment [2]. In response to the sustainable digital transformation of the construction industry based on BIM, various government policies regarding the adoption of BIM are being formulated and implemented domestically and internationally.

In 2018, the United States actively promoted the utilization of BIM in both public and private sectors by developing roadmaps and activation strategies. These policies were led by the National BIM Standard-United States (NBIMS-US), which operates under the Facility Information Council (FIC) [3]. Additionally, in 2020, the authority established a strategy for digital business automation. In the United Kingdom, the government presented a BIM roadmap named the British Standards Institution B/555 based on the BIM maturity levels in 2011 [4]. In 2017, furthermore, the Centre for Digital Built Britain (CDBB) derived a digitalization strategy for infrastructure assets [5]. Singapore, under the leadership of the Building and Construction Authority (BCA), presented a BIM roadmap in 2011 that has been

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expanding the scope by making the utilization of BIM as mandatory for enhancing construction productivity and urban management through the development of Virtual Singapore [6]. The BIM Basic Guidelines for the Construction Industry and the BIM Execution Guidelines were established by The Ministry of Land, Infrastructure and Transport of the Republic of Korea in 2020 and 2021, respectively, with the goal of enhancing productivity and achieving digitalization in the construction industry by supporting swift and accurate decision-making based on data.

In accordance with the Korean government's policies, the volume of BIM procurement in the construction industry has been increasing domestically. However, most practitioners from public ordering authorities still possess inadequate knowledge of BIM, and there is a deficiency in well-established frameworks for obtaining BIM deliverables and effectively utilizing final outcomes in BIM procurement processes. This can be attributed to the current absence of systematically structured educational curricula tailored to each BIM workflow, specifically designed for owners.

Several previous studies have indicated that the performance of project members and the overall success of projects are influenced by their background knowledge and professional experience [7]. Specifically, within the construction industry, the success of construction projects strongly hinges on the background knowledge of project members [8], [9]. Considering the heightened intricacy and unpredictability observed in contemporary construction projects, it becomes crucial for project participants to receive training in multidisciplinary practice and integrated team environments [10]. Therefore, it is imperative for both public ordering authorities and relevant industry professionals to promptly develop BIM education in order to enhance their capabilities [11].

Currently, BIM education programs primarily emphasize design and construction phases in the construction process and focus on handling BIM-related software itself. However, due to the nature of owners' tasks, there is a requirement for developing tailored educational contents that encompass the overall procedures and theories of the entire life cycle of projects, specifically addressing project management and operations.

In the initial stage, this study analysed task characteristics of owners and BIM education programs for domestic and overseas owners and conducted a thorough investigation of educational curricula among prominent domestic and overseas educational institutions offering BIM-related education. The curriculum contents were organized and analysed systematically based on construction type, process, and key software application. Additionally, A focus group interview (FGI) was conducted with BIM experts. The FGI was undertaken to identify the issues in BIM project delivery systems, the current state of BIM education programs for owners, and the required educational contents. Based on the analysis of the current state of BIM education for owners and the FGI conducted with domestic BIM experts, a customized BIM education framework for domestic owners has been derived. The presented findings are intended to serve as guidelines for developing a standardized curriculum in Korea that aligns with the future tasks and roles of owners. In fact, based on the framework proposed in this study, the Korea Institute of Construction Technology Education (KICTE) and the Ministry of Land, Infrastructure and Transport, which are major domestic construction educational institutions, have been developing BIM education curricula and conducting on-the-job training for owners since April 2023 [12]. Furthermore, the objective of this study is to promote a sustainable construction industry by continuously implementing BIM education for owners throughout the procurement process and enhancing their BIM project procurement, execution, and management capabilities. The process map of the research methodology is shown in Fig. 1.

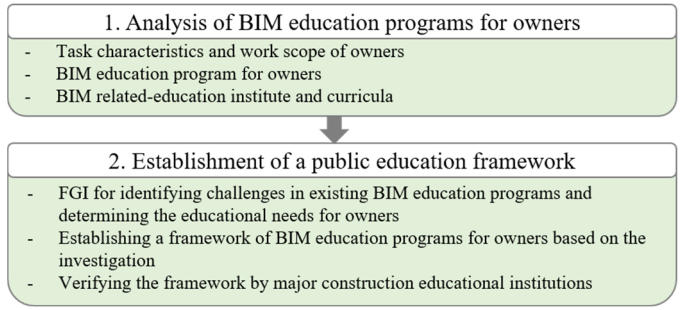


Figure 1: The process map of the research methodology.

2 ANALYSIS OF BIM EDUCATION PROGRAMS FOR OWNERS

2.1 Task characteristics and work scope of owners in public ordering authorities

The owners from public ordering authorities perform the role of BIM procurement and execution in relation to planning, bidding, evaluation, and management to facilitate comprehensive project implementation in the construction industry. According to the BIM Execution Guidelines for Owners, the public common BIM procurement process consists of nine main phases [13]. To oversee the entire BIM procurement project, owners are required to take responsibility for overall project management and possess the ability to perform quality reviews of BIM deliverables. However, most of the existing BIM education programs for owners primarily focus on curricula that do not consider the owners' specific workflow. The existing education programs mainly concentrate on handling BIM-related software itself during design and construction phases, but owners require curricula that address the level of utilization and operation of software at each project phase.

To enhance the capabilities of owners in BIM project implementation, it is necessary to develop a BIM standard education curriculum that aligns with the procurement process. The objective of BIM education for owners should cultivate the ability to fully adopt BIM and effectively operate and manage BIM procurement projects for each process. By ensuring the foundational capabilities of owners in the public sector, BIM can be smoothly and systematically applied in the domestic construction industry, enabling the successful execution of BIM procurement projects.

2.2 Current status of BIM education for owners in domestic and overseas

Various BIM education programs are being conducted abroad, and notable institutions offering education specifically targeting owners include the Crossrail Academy [14] in the United Kingdom and the BCA Academy [15] in Singapore. Both institutions operate educational programs for the entire project team (i.e., owners and contractors) and develop curricula tailored to the needs of public ordering authorities. In the case of the Crossrail Academy in the UK, construction companies, collaboration firms, and public ordering authorities access BIM Academy education organized by Bentley through academy membership. They receive personalized training aligned with their specific job requirements, focusing on effectively managing complex information generated by construction companies and collaborating firms, as well as providing education on information data flow. The BCA Academy in Singapore offers a variety of BIM-related courses for experts, managers, and

executives. Among them, the BIM Management course aims to develop competencies by providing education on BIM modelling as well as the formulation plans and project execution plans for companies adopting BIM.

Even major domestic public ordering authorities are promoting BIM education through their internal talent training programs. Examining education programs targeting owners, the Korea Land and Housing Corporation (LH) operates quarterly BIM education programs for managers and coordinators. These programs cover various topics including BIM concepts, BIM guidelines, domestic technological trends, and successful BIM cases abroad. In addition, the Korea Expressway corporation (ex) conducts annual training programs for BIM practitioners in the road construction field. These programs provide theoretical education on domestic and overseas BIM technological trends, BIM design and construction application cases, BIM performance documentation, as well as practical training in structural BIM modelling for bridges and tunnels, facility clash detection, and other related practices. Furthermore, the Korea National Railway (KR) offers practical training primarily focused on BIM program usage, construction BI, project status establishment, object modelling, BIM data review, clash detection, 4D process management, and BIM data interoperability for practitioners each year. Additionally, the Korea Institute of Construction Technology Education (KICTE) and the Ministry of Land, Infrastructure and Transport formally operate education programs for owners related to BIM procurement processes [12].

In both domestic and overseas public ordering authorities, there are instances of conducting in-house BIM education programs. However, these programs are mostly performed on an ad hoc basis as a recommendation rather than a mandatory requirement. Furthermore, the majority of BIM education programs primarily focus on introducing BIM theory and demonstrating design and construction phases through 3D modelling. Some programs also cover topics such as clash detection using BIM tools and 4D simulation, but these curricula were not sufficiently tailored to the characteristics of the practitioners' tasks. Particularly in domestic settings, the curriculum for public ordering authorities involved in BIM projects was inadequate, resulting in ineffective implementation of proper owner-oriented BIM education.

2.3 Investigation of BIM-related education institutes and curricula

This study conducted a comprehensive survey of 32 domestic and overseas educational institutions currently offering BIM-related education. The thorough investigation involved compiling a list of these institutions and examining a total of 235 curricula and 1,919 educational contents being implemented by these institutions.

Table 1 presents a summary of domestic and overseas institutions categorized by institution name, institutional classification, overseas/domestic status, emphasis on theory/practice, and utilization of software. In the case of educational institutions operating a similar ratio of theory/practice BIM education programs, they were listed multiple times. Additionally, if an education institute provides theory-oriented content or does not specify particular software for practice-oriented content, it is excluded from the survey. Furthermore, in cases where multiple software programs were utilized, they were listed repeatedly.

In Table 2, the educational curricula were analysed by classifying them according to construction type (i.e., civil engineering, architecture, others), construction process (i.e., procurement, design, construction, maintenance, others), and major software applications. Based on this analysis, current issues of the BIM educational curriculum were identified.

Based on the analysis of the curriculum provided by educational institutions and its summation in Tables 1 and 2, four insights were derived and presented in Fig. 2.

Table 1: List of analysed BIM education institutions in domestic and overseas.

n	Education institute	Class.	Overseas/ Domestic	Theory/ Practice	Software application
1	BIMLC	A	D	P	Re, Ci, Na, In, O
2	Seoul Housing and Communities Corporation	Pi	D	T & P	Re, Ar, Na, Sy, O
3	Korean Institute of BIM	I/C	D	T & P	Re, Ar, Ci, Na, In, Sy, O
4	Korea Institute of Construction Technology Education	Pi	D	P	Re, Ar, Rh, Ci, Na, In, Sy, O
5	buildingSMART Korea	I/C	D	P	Re, Na, O
…	…	…	…	…	…
28	National Taiwan University	U/E	I	P	Re, Na
29	Peter the Great St. Petersburg Polytechnic University	U/E	I	P	Re, Na
30	Zigurat_Global Institute of Technology	U/E	I	P	Re, Ar, Rh
31	School of Professional Development in Construction	U/E	I	T	Re, Ar, Ci, Na, O
32	udemy	A(O)	I	P	Re, Na, O

Note: n = Reference number; Class. = classification; A = Academy; A(O) = Academy (Online); Pi = Public institution; I/C = Institute/Conference; U/E = University/Education institution; C = Company education centre; I = International; D = Domestic; T = Theory; P = Practice; Re =Revit; Ar = Archicad; Rh = Rhino; Ci = Civil 3D; Na = Navisworks; In = Infraworks; Sy = Synchro; O = Others. The entire list can be found here: https://docs.google.com/spreadsheets/d/1ouSU6MI14P0KzCkHsiJxi9nk7S80LaUEfDpvWlqd5fY/edit?usp=sharing.

Table 2: List of analysed education curricula by construction type, process and software.

n	Education institute	Course of education	Overseas/ Domestic	Construct. type	Process
1	BIMLC	BIM 360 Webinar Series3	D	C/E	P, De, C
2	BIMLC	BIM Academy Architecture	D	A	De
3	Seoul Housing and Communities Corporation	Introduction to BIM	D	A, C/E	P, De, C
4	Korean Institute of BIM	Civil engineering BIM	D	C/E	P, De, C
5	Korean Institute of BIM	Architecture BIM	D	A	P, De, C
…	…	…	…	…	…
230	National Taiwan University	BIM Application for Engineers	I	A	De, C
231	Peter the Great St. Petersburg Polytechnic University	BIM: From sketch to digital twin	I	A	P, De, C
232	Zigurat_Global Institute of Technology	BIM Management	I	A	P, De
233	Zigurat_Global Institute of Technology	Construction Project Management	I	B	P, De
234	udemy	Autodesk BIM 360-Docs	I	A	P, De, C
235	udemy	Parametric Families for Autodesk Revit BIMLOD 200-400	I	A	P, De

Note: n = reference number; Construct. = construction; I = international; D = domestic; A = architecture; C/E = civil engineering; B = BIM fields; S = smart fields; P = project delivery; De = design; C = construction; M = maintenance; e = etc. The entire list can be found here: https://docs.google.com/spreadsheets/d/15ctUVts9tZP4jg3ko34gRYEcbfDVOEccXyBPgvQefkk/edit?usp=sharing.

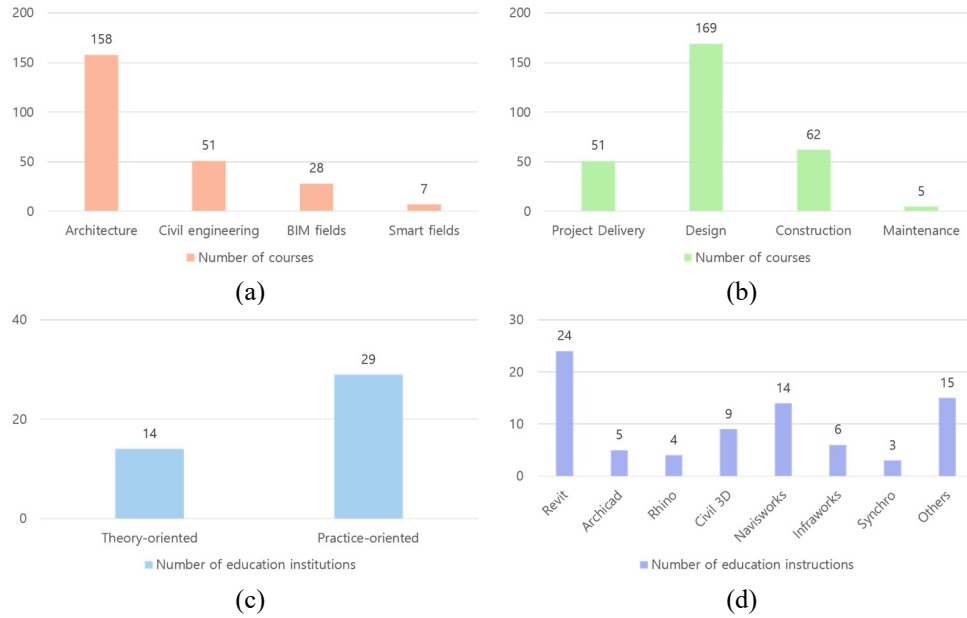


Figure 2: (a) Construction type; (b) Process; (c)Theory/Practice; and (d) Software application.

(a) Through the analysis of the educational curriculum by construction type, it was found that the architectural field accounted for the highest proportion of 68.9% in the overall curriculum. The civil engineering field had a relatively lower proportion of 22.2%. Education programs covering BIM-related contents regardless of architectural or civil engineering fields accounted for 12.2% while courses focusing on smart fields utilizing drones, laser scanning, and other technologies represented a smaller proportion of 3%.

(b) Among the analysed educational institutions, the construction lifecycle covered in the BIM curriculum was primarily focused on the design stage, accounting for 73.8%. The following stages were construction (27%) and procurement (22.2%). Education programs addressing maintenance and management using BIM data accounted for a minimal proportion of 2.1%.

(c) The analysis of contents in the BIM education programs offered by the educational institutions revealed that 67.4% of the programs were practice oriented. The practice-oriented institutions primarily focused on practical training in BIM software and planning/design aspects. The remaining 32.6% was theory-oriented, mainly operating general BIM concepts and standards.

(d) Among the educational institutions, the most widely covered BIM software was Autodesk Revit, accounting for 68.5%. The proportion of Archicad, another widely used BIM software, was only 2%. Following Revit, Navisworks by Autodesk accounted for 40%, and Civil 3D, commonly used in civil engineering, accounted for 25.7%. Other programs such as Autocad, Sketchup, and various software programs by Bentley were dealt with by multiple educational institutions.

The results of the analysis showed that both domestic and overseas BIM education curricula were primarily focused on design and construction, and these curricula mainly concentrate on BIM software applicable in design or construction phases. However, the curricula for owners are insufficient and mostly consist of comprehensive content as a common subject of BIM, rather than considering the workflow and tasks of their BIM projects. The primary goal of BIM education for owners should focus on fostering the skills required to successfully embrace BIM and efficiently oversee and manage BIM procurement projects throughout each phase. To improve the competencies of owners in implementing BIM projects, it is essential to enhance a BIM-standardized educational curriculum that aligns with the procurement process.

3 A FRAMEWORK OF BIM EDUCATION PROGRAM FOR OWNERS

3.1 Focus group interview with BIM experts from public ordering authorities

The main purpose of the FGI in this paper is to identify the challenges related to BIM procurement and ascertain the educational needs. FGI was conducted with six prominent professionals actively engaged in domestic BIM projects. They are experienced professionals with over 10 years of experience in the relevant field, having implemented more than 10 BIM projects. The group is composed of individuals working in major domestic public ordering authorities, engineering companies, and academic institutions in the fields of architecture and civil engineering. The FGI was conducted through online video conferences after prior coordination with the interviewees. Each of the interviewees was interviewed for half an hour. The interviewees were asked questions pertaining to two main topics: (i) issues associated with existing BIM procurement processes, and (ii) necessary BIM education programs and contents for owners. Various opinions were derived regarding the two main topics, and among them, common and essential viewpoints were summarized in Table 3.

Table 3: The summary of FGI contents

Classification	The summary of FGI contents
Issues of existing BIM procurement processes and BIM education programs for owners	1. Public ordering authorities experience a non-smooth decision-making process due to the limited understanding of BIM. 2. While public ordering authorities are making some efforts to provide internal BIM education, it is currently limited to a one-time training session. 3. There is a lack of customized BIM education programs tailored specifically for owners in public ordering authorities.
Required BIM educational contents for owners	1. The fundamental definition of BIM, reasons for the necessity of BIM, and implications of BIM. 2. Organizational structure and collaboration in relation to BIM. 3. Structures, writing standards, and review methods of documents (i.e., BIM requirements, BIM execution plans (BEP), and request for information (RFI)) during a procurement procedure. 4. Design BIM (principles of 3D modelling, 4D, and 5D), Construction BIM (the management of process and quantity take-off).

Upon summarizing the interview contents, the following implications were derived: (1) current education status; (2) education programs required by the owner. Firstly, regarding the education status, it was identified that the owner needs to enhance their BIM capabilities. However, the existing curriculum for the owner is limited to one-time education due to its absence. Furthermore, the curriculum is not developed internally to meet the specific needs of owners but rather relies on external educational institutions and their instructor's curricula composed with other stakeholders in BIM projects. Therefore, the development of an education curriculum tailored to the owner's education objectives is necessary. Secondly, it is necessary to establish a curriculum that progresses according to the owner's proficiency level, encompassing both basic and advanced stages, while also accurately representing the entire BIM procurement process including planning, bidding, evaluation, and management. Moreover, the educational content should encompass a comprehensive understanding of BIM projects, including BIM theories, collaborative working with BIM, concepts related to BIM software, BIM documents as well as BIM deliverables, as demonstrated in Table 3. In addition, it is necessary to diversify the type of educational contents, not merely categorizing them into theory and practice, but aligning them with the purpose of enhancing the BIM execution capabilities of owners.

3.2 Development of a framework of BIM education programs for owners

Based on the issues related to a BIM procurement process and education programs for owners derived from Sections 2 and 3.1, a customized framework of BIM education programs for owners was developed, as shown in Fig. 3. When constructing the framework, several factors were taken into consideration. Firstly, integration with the BIM Basic Guidelines for the Construction Industry and the BIM Execution Guidelines of the Ministry of Land, Infrastructure and Transport was ensured. Secondly, aligning with the actual BIM execution tasks of the public ordering authorities was emphasized. Thirdly, education programs tailored to the proficiency level of each owner were developed. Lastly, diverse types of education programs were considered.

The BIM Basic Guidelines for the Construction Industry provide the basic and common BIM application procedures, which cover project procurement, performance and product delivery management [16]. These guidelines also outline specific tasks performed by each stakeholder in a step-by-step manner. Building upon these BIM application procedures, the tasks performed by owners are divided into nine stages and integrated with the actual BIM execution tasks of the public ordering authority. The framework enables the efficient use of BIM throughout all stages of a construction project, from pre-project preparation to maintenance phase. It facilitates the effective implementation of tasks using BIM throughout the entire lifecycle of a construction project.

Moreover, it allows for the provision of customized curricula tailored to the objectives of owners' tasks, such as BIM data and BIM deliverables review. The detailed training curriculum is structured into basic and advanced levels, enabling owners to learn the education content in a step-by-step manner according to their level. The educational content encompasses not only software usage focused on design or construction but also includes theory, case study, policy, practical exercise, and demonstration, diversifying the learning experience and promoting efficient learning in relation to each educational topic.

In accordance with the framework, Fig. 4 presents an example of BIM education curricula tailored for owners. The curricula focus on the basic level and cover essential topics such as BIM concepts, BIM requirements, managing BIM projects, and reviewing BIM execution

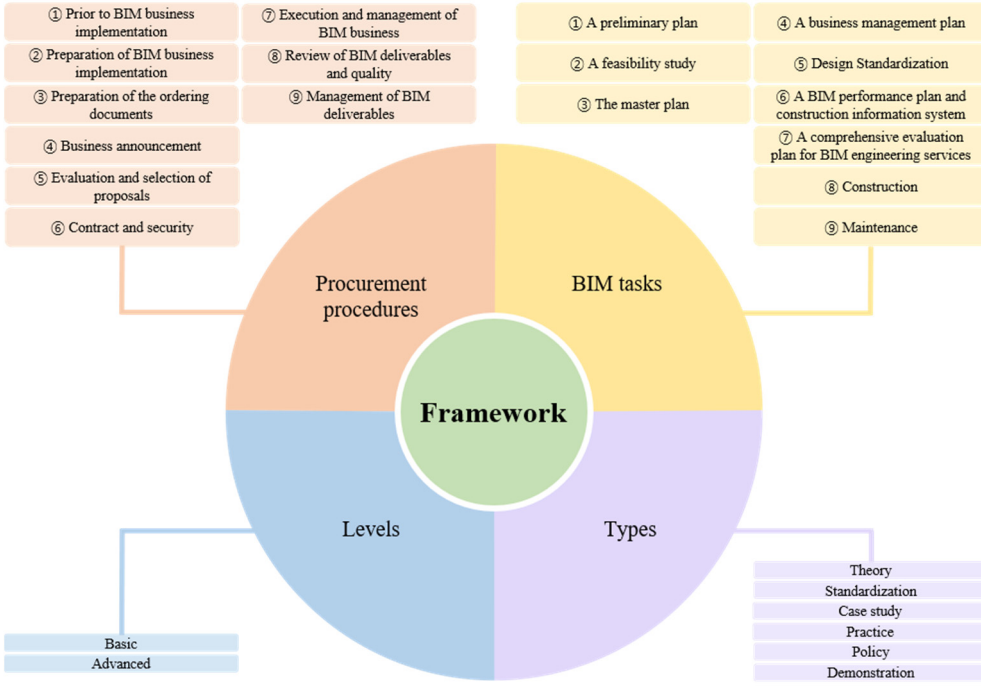
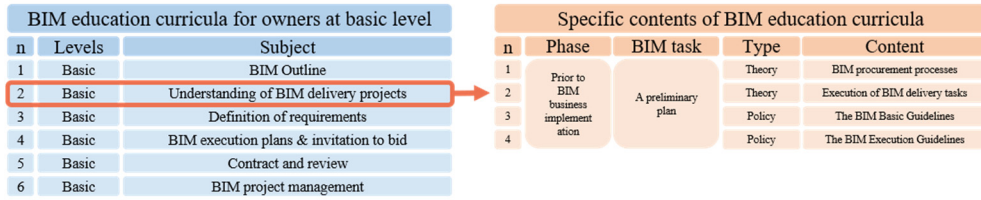


Figure 3: A framework of the BIM education program for owners.



BIM education curricula for owners at basic level

n	Levels	Subject
1	Basic	BIM Outline
2	Basic	Understanding of BIM delivery projects
3	Basic	Definition of requirements
4	Basic	BIM execution plans & invitation to bid
5	Basic	Contract and review
6	Basic	BIM project management

Specific contents of BIM education curricula

n	Phase	BIM task	Type	Content
1	Prior to BIM business implement ation	A preliminary plan	Theory	BIM procurement processes
2			Theory	Execution of BIM delivery tasks
3			Policy	The BIM Basic Guidelines
4			Policy	The BIM Execution Guidelines

Figure 4: An example of BIM education curricula for owners from the framework

plans. Specific contents of the subject are systematically organized based on the procurement procedure, BIM tasks, and education types. For instance, the subject titled 'Understanding BIM delivery projects' at the basic level consists of four specific contents. These contents address the phase of prior to BIM business implementation, the BIM task associated with preliminary planning, and encompass types of both theory and policy.

Future research aims to derive standardized education curricula for domestic owners and provide them with continuous and relevant education considering BIM procurement workflow and procedures based on the customized BIM framework presented in this study. Currently, the Korea Institute of Construction Technology Education (KICTE) and the Ministry of Land, Infrastructure and Transport officially develop BIM programs for owners based on the framework proposed in this study and operate on-the-job training for practitioners working in public ordering authorities. By establishing and promoting BIM

education for owners at the national level, the purpose is to foster sustainable digitalization and improve productivity in the construction industry.

4 CONCLUSIONS

The aim of this study is to develop a framework for creating customized BIM education standard curriculums for owners in public ordering authorities. This research analysed task characteristics of owners, the current state of BIM education for both domestic and overseas, as well as the educational programs and curricula offered by major BIM training institutions. Additionally, FGI was conducted with prominent BIM experts actively engaged in domestic public ordering authorities. Through this process, the study identified the challenges and issues around BIM education for owners and aimed to propose a framework to develop a standardized curriculum that aligns with domestic BIM-related government policies and practices and provides owners with practical, industry-focused education in accordance with government guidelines and procedures. This research is in the initial stage of studying and arranging a framework for BIM education programs for domestic owners, even though it has been verified by major construction educational institutions such as the Korea Institute of Construction Technology Education (KICTE) and the Ministry of Land, Infrastructure and Transport. To pursue sustainable digitalization and maximize productivity in the construction industry, future research should focus on implementing a continuous process of operating various customized BIM curricula for the purpose of domestic owners based on the framework. This process would involve offering these curricula to owners in public ordering authorities, going through trials and errors, and continuously updating and improving the framework. Furthermore, based on the BIM education framework for owners, it will be necessary to develop private sector BIM standard education programs for architects, contractors, supervisors, and other professionals to meet the understanding and requirements of owners.

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