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Digital Transformation in Developing Countries: A Study into BIM Adoption in Thai Design and Engineering SMEs

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Abstract**—**Building Information Modelling (BIM) is the major technological trend among built environment organisations. Digitalising businesses and operations, BIM brings forth a digital transformation in any built environment industry. The adoption of BIM presents challenges for organisations, especially Small- and Medium-sized Enterprises (SMEs). The main problem for built environment SMEs is the lack of project actors with adequate BIM competences. The research highlights learning in projects as the key and explores into the learning of BIM in projects of designers and engineers within Thai design and engineering SMEs. The study uncovers three impeding attributes which are: a) lack of English proficiency; b) unfamiliarity with digital technologies; and c) absence of public standards. This research expands on the literature of BIM competences and adoption.

Keywords**—**BIM competences and adoption, digital transformation, learning in projects, SMEs, and developing built environment industry.

I. INTRODUCTION

THE adoption of BIM digitalises built environment businesses and operations and generates a digital transformation within built environment industries [1], [2]. Among other available digital technologies, BIM radically reforms existing paradigm of built environment management and production [3], [4]. BIM adoption exhibits challenges for built environment organisations, particularly for SMEs [5], [6]. SMEs are accounted for the majority of organisations within built environment sector [5], [7]. The lack of project actors with sufficient competences in BIM is the principal impediment for built environment SMEs [5], [7].

BIM competences are personal traits and expertise required by an individual in completing BIM-related tasks [8]-[10]. Project works are the norm of built environment operations [11], [12]. Projects are a suitable platform to correspond to a rapidly changing technological and market environment [13]. Learning is intensive in projects as they are the main source for innovative ideas and knowledge [14], [15]. Learning in projects is highlighted by this research as the key to enhance BIM competences in project actors.

The research explores into the learning of BIM in projects in Thai built environment SMEs. The Thai built environment industry is considered as developing and is in an early stage of a digital transformation from BIM adoption. With limited research on BIM adoption in developing industries, the study examines design and engineering SMEs. BIM is majorly exercised in the design and pre-construction stages [16]. The research interviews designers and engineers as they are the most active project players [16], [17]. The next section of this paper explains relevant concepts of BIM learning in projects. The research methodology, findings, and discussion are presented later. The paper ends with both practical and theoretical conclusions.

II. DIGITAL TECHNOLOGY OF BIM AND LEARNING IN PROJECTS

A. BIM

Recognised through various names such as 'digital construction tool' [4], 'Virtual Design and Construction' (VDC) [18], and 'construction informatics' [19], BIM is a digital technology that digitalises built environment businesses and operations into a more integrated management of information and project actors [2], [17]. A technology is not only technological, but also embodies political, psychological, economic, and professional commitments, skills, prejudices, possibilities, and constraints [20]. BIM represents both physical and functional facility-related properties that can be collaboratively accessed by project members throughout a project lifecycle [19], [21]. BIM politically, technologically, and procedurally transits the built environment production into a more integrated management of information and project actors [4].

The main functions of BIM are project visualisation, rapid generation of reports and digital models, and a collaboration platform for project members [22], [23]. BIM radically transforms project management, work practices, staff skills, relationships between project parties, and contractual arrangement of built environment industry [3], [4]. The adoption of BIM in organisations causes a digital transformation. Digital transformation refers to profound changes taking place within an industry through the implementation of digital technologies [24], [25].

A digital transformation requires a supporting infrastructure

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[12], [26]. This is to provide a direction, guidelines, and a structure for organisations to follow [27]. Government mandate BIM standards are a substantial part in the formation of the supporting infrastructure to BIM, as well as a major force in driving the digital transformation from BIM forward [28]. Standards act as an invincible structure that binds disciplines and ensures that actions, needs, and problems of parties are conversant [29], [30]. In developed industries such as the UK, US, Singapore, Finland, and Australia, BIM standards command and control various aspects of built environment operations such as collaboration procedures, production qualities and outputs, and minimum requirements of works to the sharing of related knowledge of BIM [28], [30]. While research on standards and supporting infrastructure of BIM are initial, it is evident of how standards allow fluent communication and collaboration between different project parties, especially in an international setting [27].

BIM was found to be primarily exercised by architectural consultancies, followed by engineering consultancies during the design and pre-construction stages [2], [17], [22]. Notably within design and architectural consultancies, factors to BIM adoption were categorised into five major streams [17]. The five streams were *motivation*, *technical defects*, *BIM capability*, *management support,* and *knowledge structure* [17].

B. BIM Adoption

Motivation played the most significant part in the adoption of BIM [17]. It was referred to as the extent to which project actors are motivated to exercise the technology [2], [17]. Motivation is formed by cultural, material, mental, social, and temporal resources [5]. Reasons for an unmotivated project actor could range from the lack of interests, money, or time, to something more specific such as technophobia and digital anxiety [5], [8]. Economic benefits, effectiveness, and efficiency of BIM were identified as main sources of motivation [17], [22].

Technical defect was identified to come after motivation, in terms of its significance to BIM adoption [17]. Technical defects related to complexity and compatibility of BIM to other software used within projects and an organisation [2], [17]. Although interoperability was underlined as one of the benefits that the technology brings, it would not be effective unless all parties implement compatible software and technologies [2], [22]. This generated excessive costs for organisations [5].

BIM capability came third in its relevance to BIM adoption [17]. BIM capability could be referred as BIM-related knowledge and expertise in executing BIM activities [16], [17]. This stream related to the lack of BIM competences in individuals which causes uneven levels of BIM competences within a project team, an organisation, and within an industry [4], [31]. It also affected collaborations between different project parties [10], [31]. This issue generates potentials for BIM education and training providers [16].

Management support and *knowledge structure* were evaluated as insignificant [17]. Management support is applied to any incentives or assistances in adopting BIM by managerial actors [32]. This extended to both formal and informal education and trainings, as well as an Information Technology (IT) infrastructure provided within an organisation [2]. Some organisations perceived BIM as another generic IT system, rather than the core element of businesses [17], [32]. Knowledge referred to as any related knowledge required for successful implementation of BIM [17]. Such knowledge ranged from properties of building material, environment performances, costs, programming, and construction laws to understanding of local culture and construction drawings [9], [17]. Project actors are required to possess these mention knowledges to seamlessly manoeuvre BIM in practice [17].

The adoption of BIM presents greater challenges for built environment SMEs [5], [6]. Larger organisations are more adaptive to digital transformation due to their previous experience, investment opportunities, and power [1], [6]. Academically and practically, most technology adoption model are oriented more towards larger organisations as they contain more formal procedures [7], [33].

SMEs in general are technologically weak, lack managerial expertise and resources, and contain insufficient formal education and training [5], [34]. They are mainly motivated to survive and to solve immediate problems, rather than organisational growth [35]. Alternatively, SMEs can utilise any technology in a substantial manner, if such technology can be dovetailed into their existing organisational capabilities [5], [36]. More research is necessary from the perspective of built environment SMEs in BIM adoption [5]. For built environment SMEs, BIM competences [17], with focuses in the *lack of project actors with adequate BIM competences* is the major complication [2], [5], [6].

C. BIM Competences

Competences in BIM refer to expertise, personal traits, professional knowledge, and technical abilities of individuals in completing BIM-related tasks [8], [9]. Competences of individuals contribute directly to capabilities of a project team and an organisation [10], [13]. Competences, in general, can be categorised into a) hard competence, relates to knowledge, skills, and abilities of an individual to execute activities and b) soft competence, corresponds to personal behaviours, traits, and motives in working [37], [38].

With BIM competences, competences can be classified into four main areas which are: a) BIM actor characteristic; b) education and experience; c) task expectation; and d) structural and cultural system upholding the BIM actor role [31]. An extensive analysis on BIM competences in relation to each specific BIM-related role within a project yields how BIM competences can be categorised into the *essential competency*, the *common competency*, and the *job-specific competency* [10]. Table I presents competences within each categorisation of BIM competences as displayed in [10].

There are four units of analysis in discussions of competences [9]. The units are individual, group, project, and organisation [9], [39], where studies on the individual level have been receiving attentions [10], [31]. BIM competences can be acquired or learned through four main modes of *formal education*, *on-the-job training*, *professional development*, and *informal experiential gain* [2], [8], [9]. All modes of BIM learning occur more intensively at the project level [8], [40]. Projects are the norm of built environment operations [41], [42] and the main source for innovative ideas and knowledge [14].

TABLE I
BIM COMPETENCY AND COMPETENCES [10]

BIM competency	BIM competences
Essential competency	Establishing and maintaining interpersonal relationships
	Interacting with computer
	BIM-related work experience
	Technical vocational education
	Engineering & technology
	Speaking
Common competency	Communication with supervisors and peers
	Guiding, directing, and motivating subordinates
	Providing consultation and advice
	Post-secondary degree
	Documenting & recording
	Evaluating information to determine compliance with standards
	Monitoring data on quality, costs, waste, and etc.
	Drafting, laying out, specifying technical advice
	Thinking creatively
	Design
	Cooperation
Job-specific competency	Developing new product, services, and procedures
	Having an opportunity for independence freedom
	Having control over units or department
	Scheduling works and activities for others
	Initiative
	Mechanical
	Providing high quality products
	Building & construction
	Technical design
	Training and teaching others
	Time management
	Leadership
	Computer & electronics
	Determining workflows or order of tasks
	Coordinating works
	License
	English & foreign language
	Law & government
	Administrative
	Personal resource management
	Graduate degree
	Making solving problems
	Writing skills
	Quality control analysis

D. Learning in Projects

A project can be characterised by having: a) a specific objective within certain performance specifications; b) limited resources; c) defined start and end dates; d) responsible project managers and project teams; and e) knowledge needs [15], [43]. Projects are the suitable platform in responding to rapid technological, economical, and operational changes within an industry [44]. Projects are also used to pilot and achieve strategic and operational objectives [42]. Project works provide a unique arena for new knowledge, ideas, and innovation to emerge from their fluid, temporary, and inter-disciplinary nature [14], [15].

Learning refers to processes where knowledge is created, distributed, and communicated through and across an organisation within consensual validity and integration into organisational strategy and management [45]. It is the cultivation of knowledge and experience that occurs within and across any organisational units of analysis [13]. Situates around the project setting, learning in projects ranges from within and across projects, to being from previous completed projects [46]. It can be divided into two major views which are a) technical view, focuses on the processing and responding to information and b) social view, acknowledges learning as a result of social interactions that helps people make sense of their working experience [11]. Comparably, learning in projects can be categorised into the Sender/receiver and the Social learning approaches [41]. Relying more towards the nature of knowledge being learned, the former approach weights more on the storage, retrieval, and transfer of explicit knowledge. The latter approach deals specifically with tacit knowledge learning and the contextual nature of projects and the organisation that facilitates learning [41].

More research into BIM adoption and competences, in relation to learning in projects in built environment SMEs is necessary. Much research has only examined into larger organisations, while specific literature on BIM competences is scarce. Research on different contextual settings such as in developing industries are also limited and can yield valuable insights. The next section elaborates on the research methodology, as well as the area of investigation of this research paper. It is followed by the research findings, discussion, and conclusion.

III. RESEARCH METHODOLOGY

A. Research Setting and Question

With an attention to examine the learning of BIM in projects within built environment SMEs, the research explores into the context of the Thai built environment sector. Thailand is a country within the regional intergovernmental organisations of ASEAN (Association of Southeast Asian Nations) [47]. Considered as a developing sector, the Thai built environment industry is one of the main driving forces in the economic growth of the country [48], [49]. It contains the amount of £22 billion in investment value [50], [51].

The industry is now under a major development from the economic stimulus of £8 billion to improve country-wide public infrastructure [48], [52]. This stimulus generates greater collaboration between national and international organisations, as well as demands for a more efficient built environment production. BIM is the current digital transformation of the industry [53], [54]. However, its adoption is light, despite being introduced for nearly 20 years [54].

For Thai built environment SMEs, the main problem situates in the lack of project actors with adequate BIM competences [53]. This corresponds to research of [2], [5], [55]. Built environment SMEs account for 99% of organisations within the sector. There is also minimum research on BIM within the Thai built environment industry. Contributing to the research void, as well as laying a foundation for future research, this research centralises around the research question of "what are attributes that impede the learning of BIM in projects within Thai built environment SMEs?"

B. Research Approaches

The study stands on the constructivist ontology and the interpretivism epistemology. The leaning of BIM in projects is personal. It relies intensively on both technical and social aspects within a project team and an organisation [11], [37], [41]. The research is based on semi-structured interviews of designers and engineers within Thai design and engineering SMEs. Semi-structured interviews are exercised heavily in qualitative research to examine topics and dive deeply into personal and social matters with a certain level of structure [55], [56]. This research takes on the romanticism view of interview research. An interviewer acts as an empathetic listener to unfold the real-life experience and complex social reality of an interviewee [56].

Designers and engineers are project roles operating hands-on with BIM [16], [54]. BIM is also principally utilised by design and engineering consultancies in design and pre-construction phases [2], [17]. Focuses of this research are placed towards experience of project actors in learning BIM in projects that they are in. Project works are a setting where knowledge and innovative ideas emerge [13], [15]. Each interview is in-depth and last around one hour.

C. Data Collection

Nineteen designers and engineers participated in this research. Each interviewee came from a different Thai design and engineering SMEs. These SMEs were considered as leaders in BIM adoption in Thailand. Details of each interviewee could be found in Table II.

Each interviewee was assigned an identifier of *IN* in front. The interviewing language was Thai as not all designers and engineers can communicate in English at ease. Semi-structured interview questions were categorised into two parts of initiating and following-up. The initiating questions were based on questions such as "what are your thoughts on the way that you are learning how to use BIM on projects?" and "what do you think are attributes to impede or enhance your learning and using of BIM on projects?" The following up questions were constructed on questions which are "can you please elaborate more on the attribute to BIM learning you have mentioned?" and "amongst all attributes that you have said, which of them is the most significant and why?"

TABLE II
DETAILS OF EACH INTERVIEWEE

Interviewee (IN)	Project roles	Project types	Org. sizes	Adoption year
IN01	Interior architects & BIM manager	Office, well-being, & residential	Medium	2014
IN02	Architect	Commercial	Medium	2014
IN03	Mechanical engineer & BIM manager	Commercial & residential	Medium	2017
IN04	Civil engineer & BIM coordinator	High-rise residential & commercial	Medium	2016
IN05	Project architect	High-rise residential & commercial	Medium	2015
IN06	Project architect & BIM manager	High-rise residential & commercial	Medium	2014
IN07	Project architect & managing director	Residential	Small	2016
IN08	Landscape architect & project architect	Landscape design	Medium	2016
IN09	Civil engineer & BIM manager	High-rise residential & well-being	Medium	2019
IN10	Project engineer & BIM manager	Residential	Medium	2015
IN11	Project architect & BIM manager	Sky train	Small	2019
IN12	Project architect & managing director	Residential	Small	2015
IN13	Project architect & BIM manager	Residential & commercial	Medium	2014
IN14	Project architect & BIM manager	Commercial	Small	2012
IN15	Architect & BIM manager	Commercial	Medium	2007
IN16	Project engineer	Residential & commercial	Medium	2014
IN17	Project engineer & BIM manager	Residential & well-being	Medium	2013
IN18	Project engineer & BIM manager	Commercial	Medium	2013
IN19	Project architect & managing director	Infrastructure	Medium	2009

D. Data Analysis

Interviews were recorded and anonymously translated, transcribed, and imported into NVivo qualitative data analysis software. NVivo supported this research only in the management of data and emerging ideas [57]. Through both deductive and inductive coding approaches, topics and ideas emerged from each interview were coded into nodes and later categorised into themes. The research employed streams in BIM adoption in [17] as themes. Attributing elements that fall within each stream would be coded into nodes. For example, if an interviewee mentioned that he/she is not interested in using BIM as they have deadlines to meet, the passage would be coded under a node of *lack of interests from project deadlines* and fell within the theme of *motivation*. The researchers were aware of any possible emergent topics and ideas. If an interviewee mentioned that they could not collaborate effectively from the absence of public BIM standards, the passage would be coded under a node of *collaborative issue from the lack of BIM standards* and would be classified under a theme of *supporting infrastructure* [28].

IV. Research Finding

From the interviews, the research uncovered three main attributes that impede the learning of BIM in projects within Thai design and engineering SMEs. These impeding attributes acted as a barrier for effective digital transformation in the Thai built environment industry. The attributes were: a) *lack of English proficiency in project actors*; b) *unfamiliarity with digital technologies*; and c) *absence of public standards in BIM*. From 19 interviews, 16 or 84.4% reported at least one attributes impeding the learning of BIM in projects. Four interviewees stated two, while one interviewee affirmed all three. It was also important that there might be other attributes for designers and engineers. However, they might not be significant enough to be brought up during interviews. Table III illustrated the attributes raised by each interviewee.

TABLE III
Impeding Attributes to the Learning of BIM Raised by Interviewees

	1: Lack of English proficiency in project actors	2: Unfamiliarity with digital technology	3: Absence of public standards
IN01	x		
IN02	x		
IN03			x
IN04			
IN05			x
IN06	x	x	x
IN07	x		x
IN08	x		x
IN09		x	x
IN10	x		x
IN11			x
IN12		x	
IN13			
IN14			x
IN15			
IN16	x		
IN17	x		
IN18		x	
IN19	x		
Total	9	4	9
Percentages	47.4%	21.1%	47.4%

Attribute 1, *'lack of English proficiency in project actors'* and Attribute 3, *'absence of public standards'* were equally raised by nine interviewees out of 19. Each accounted for 47.4%. Attribute 2, *'unfamiliarity with digital technologies'* was brought up by four interviewees or 21.1%. Three interviewees did not report any complication in the learning of BIM in projects.

A. Lack of English Proficiency in Project Actors

Lack of English proficiency in project actors implied to how English language became an impeding attribute for designers and engineers in learning BIM in projects. The difficulty presented itself as project actors were accessing external knowledge sources such as online tutorials and forums. IN01, who is also a BIM manager explained "… the major factor is always going to be English proficiency. All the tutorials online are in English, and again, it is really hard for them to learn things by themselves …" IN08 added "It is really hard for these people though, since their English is not really good enough to understand everything said within existing tutorials." Similar to IN01 and IN08, IN10 who is also a BIM manager stated "… I did ask them to go look up online tutorials and videos as well. However, their English are not that good or not at the level to be learning something that complicated by themselves."

Equivalent assertions were brought up by IN17 and IN19. Additionally, IN17 elaborated "… if they have problems with BIM, they can search online for that. However, they do not have enough knowledge to find that. It is really hard for them to type a whole sentence to find specific things on BIM online." This factor also presented itself in navigating through BIM-related forums, where discussions on BIM are being made. IN02 included "When you go on these forums, they are all in English. That means you need a certain level of English proficiency to understand and navigate yourself through the website."

Supports from colleagues and/or managerial actors were mentioned as a counter measure. Varieties of specific measure were stated by the interviewees. IN06, who is a project architect and a BIM manager explained "We need to show them that they can do this, even though it might take them longer to learn but we need to encourage them to push forward." IN07, who is a project architect and also a managing director added "… it is usually me who would be translating the videos back to everyone." However, this factor was still impeding the learning of BIM as it presented a difficulty to effectively collaborate amongst project parties. IN16 enhanced "BIM also requires you and your team to be speaking with the same language … this means that they need to understand immediately of terms used in the program in BIM language, which often are in English. That is why it takes so long for Thai organisations to transit to BIM."

B. Unfamiliarity with Digital Technologies

Unfamiliarity with digital technologies referred to how experience on digital technologies such as computers and certain software allow some project actors to be more adaptive in learning BIM in projects. IN06 pointed out "… it is clearly better for them to learn BIM since they are more used to working on a computer and operating on 3D models."

Additionally, IN06 was referring this impeding attribute to generations of project actors. IN06 mentioned "Generations of people is the main factor … for older generation, it is slightly more challenging for them to get used to this." Contributing to this argument, IN09 added "… the newer generation of engineers would already know a bit about BIM. They grew up with using computers and they basically learn a lot quicker compared to senior project actors." IN09 later elaborated "… for younger project actors, we can just tell them … and they would pick them up in no time … for senior project actors, we had to tell them step by step of everything." Analogous statements were mentioned by IN12. However, IN18 highlighted that it also depends on the practical knowledge and experience. IN18 clarified "… for the younger ones, it is also about the lack of actual construction knowledge or the practical knowledge of how buildings are built … it is the main key that separate the great learner from the average learner." IN18 later extended "Knowing how to work on BIM and actually being experienced on BIM are different. Finding the right balance is really hard."

C. Absence of Public Standards

Absence of public standards presented the lack of public guidelines and/or standardised procedures for design and engineering SMEs to follow when working on projects that require the use of BIM. It created confusions between organisations and impeded the learning of BIM in projects for project actors. IN03, who is a mechanical engineer and a BIM manager explained "… we are trying to have our own system. At the same time, others are trying to develop their own as well … it would be really great to have a common standard that everyone can work on." Comparable claims were made by IN05, IN06, and IN07. IN07 specifically added "… we often have to ask other consultant first to see the middle ground where it is best to work together. That slows things down quite a lot." IN10 also highlighted "Learning from other projects is really hard, especially when there are no actual standards across the country."

The absence of public standards in BIM generated confusion for organisations. Once an organisation chose a standard to follow, the costs and time to change as works progress might be too high, especially in SMEs. IN14 extended "… in Thailand, each client or developer would usually have their own standards … there are a lot of debates about how or where the standards should come from. Should we follow the US, UK, or the Australia?" Interviewees also viewed standards as a reference point to raise common understandings of BIM amongst project actors. IN08 mentioned "Standards are good as a reference point. It is just to make sure that everyone understands the same thing in producing works." IN05 stressed "I think, another thing that smoothens works is the standards. This is more about working between firms and collaborate."

Calls were made for the government to take initiatives. IN05 mentioned "… I would like to add that we need more support from the government." IN11 confirmed "… the Thai government has no idea of what BIM actually is … with this kind of limited attention and supports from the overseeing institution, it hardly adds any kind of pushes to make people use BIM more." IN11 later added "The architectural and the engineering institutions are also very far behind. Their first release of the standards was not that effective."

V. Discussion

Despite BIM being introduced nearly 20 years ago, most design and engineering SMEs started their adoption after 2010. These SMEs were also identified as early adopters of BIM. This signified how slow the Thai built environment industry is with the digital transformation from BIM. The research unfolded three attributes that impede the learning of BIM in projects for designers and engineers. They related more to the technical view of learning in projects [11]. The research identified Attribute 1, *lack of English proficiency in project actors* and Attribute 3, *absence of public standards* as more significant than Attribute 2. The attributes discovered prompted discussions of BIM learning on the individual and the industry levels of analysis. The research categorised them into themes of *knowledge structure* and *supporting infrastructure*.

A. Knowledge Structure to BIM Learning in Projects

Attribute 1 and Attribute 2 were categorised under the theme of knowledge structure from [17]. The findings of both attributes highlighted the concept of individual competences within BIM adoption literature. Reasons for the emergence of these attributes resulted from the fact that English is not the official language in Thailand, as well as the low level of familiarity to digital technologies of Thai workforces. Expanded on [9], [17], literature of BIM adoption and competences should consider both attributes in discussions. Especially, if the discussions circulate around the context of developing industries. Both attributes also opposed [17] by emphasising the significance of knowledge structure to the adoption of BIM. However, it was argued within [17] that an exploration of different project roles could yield diverse results.

Both attributes also extended on BIM competences literature of [10], [31]. In [31], attributes found underlined the education and experience area of BIM competences. The two attributes reflected the importance of knowledge needed in overcoming obstacles in operating BIM. Attributes of English proficiency and digital familiarity were also mentioned in [10]. However, in [10], digital familiarity was classified as the essential competency for all project actors, while English language was stressed as the job-specific competency that was necessary for only the senior architect and BIM manager. This research argued that English language should also be classified as the essential competency for all project actors. Especially in countries that English language is not listed as the official language.

The research identified Attribute 1, lack of English proficiency in project actors as more significant. It could be argued that this might be due to the fact that project actors could be more familiar with digital technologies in a faster fashion than being proficient in English language. The study would like to recommend that investments in building up English proficiency in project actors should be made in parallel with formal and informal education and training in BIM. Problems associated with the lack of English proficiency were related mainly to difficulties in accessing and understanding BIM-related knowledge from external sources such as online tutorials and forums. Having English language educations in parallel could bridge the gap and help answer emergent questions. The research would also like to suggest that English language should be emphasised more in schools and university educations.

B. Supporting Infrastructure to BIM Learning in Projects

Attribute 3 signified that the supporting infrastructure to the digital transformation from BIM in the Thai built environment industry is far from completion. Together with how BIM is more supported in other built environment sectors [2], this reflected how the Thai government and other overseeing institutions should pay a closer attention to the adoption of BIM, especially in SMEs. This yielded an opportunity for the public sector to invest more into BIM-related research and provide a concrete roadmap of the digital transformation from BIM for organisations to follow. The research identified this attribute to be as significant as Attribute 1. This finding supported [28] on how public standards are a major force to drive forward BIM adoption of the industry. The finding also denoted that Thai built environment organisations are lacking a reference point for collaboration within a project. As stated in [27], [30], public standards serve as a framework and a guideline for organisations within a project to follow, as well as to leverage their understanding on BIM operations. This attribute was emergent. Investigations in consequences of the absence of public standards and incomplete supporting infrastructure in BIM were minimum, especially in the context of a developing country such as Thailand. The research would like to suggest for a collaboration between the government and built environment organisations in the formation of public standards of BIM and making sure that the standards developed is widely acknowledged by organisations. Standards from developed built environment industries such as the British and the American were already employed by some organisations. Some attempts had been made in translating international standards to be used within the industry. Organisations and institutions could share lessons learned and insights in the formation of public standards in BIM that are compatible to the Thai built environment industry.

VI. Conclusion

The research uncovered three attributes that impede the learning of BIM in projects for designers and engineers within Thai design and engineering SMEs. Projects were a setting that encapsulates the quintessence of individuals, organisations, and an industry. The attributes were: a) lack of English proficiency in project actors; b) unfamiliarity with digital technologies; and c) absence of public standards. Lack of English proficiency in project actors and absence of public standards in BIM attributes were identified as more significant in the learning of BIM in projects. These attributes presented complications and areas of improvement in the digital transformation from BIM in the Thai built environment industry. The study categorised the three attributes into the knowledge structure and the supporting infrastructure theme of BIM adoption.

Built environment SMEs were recommended to invest in building up English proficiency in parallel with education and training of BIM. The research also suggested for English language to be emphasised more in schools and universities. A collaboration between institutions and organisations to formulate public standards in BIM was also advised. The research expanded on literature of BIM adoption and competences, as well as learning in projects. More investigations in different developing industries could foster greater understanding on BIM adoption, as well as a digital transformation in the built environment industry.

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