Establishing a Collaboration Model for BIM Training Program in Technical and Vocational Education and Training (TVET): A Vietnam case study

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Abstract. This study presents an institution-industry collaboration model for BIM training with a case study of a TVET college in Vietnam. The model focuses on the most needed and practical skills to fit with the actual requirements of the labour market. It also helps to educate BIM technicians that meet the industry standards in a reasonable training time. In consultation with the industrial partners, the College defined six learning outcomes and 18 competencies for the BIM program to ensure that students can perform the BIM technician job when finishing the program. The findings present the benefits of the collaboration training model that could provide a better learning environment for students and help to narrow the gap between educational outcomes and industry needs. Furthermore, a questionnaire survey was conducted targeting the industrial partners and graduated students to assess the importance of the designed competencies. Feedback from the participants shows that collaboration and self-development skills are the most critical skills for the BIM technicians, so the BIM program should develop related courses aligned with the learning outcomes.

1. Introduction

Building Information Modeling (BIM) has been recognised as one of the platforms for digital transformation in the built environment. This transformation brings various opportunities for performance improvement that benefit all the players in the field [1]. Therefore, BIM applications have been introduced and mandated in many countries such as the UK, Norway, Finland, Singapore, South Korea and Denmark [2]. BIM has been increasingly adopted in different phases in the life-cycle of construction projects, which in turn has increased the demand for BIM professionals. Many countries experience a shortage of skilled BIM personnel [3, 4]. Different BIM-related jobs are hiring, such as BIM manager, BIM coordinator, BIM technician, BIM director, and BIM designer requires different skill sets [4]. Usually BIM specialists require a combination of technological and management skills, but each role might have particular needs and requirements [3]. Therefore, identifying essential skill sets at different levels of BIM jobs is crucial so the BIM curriculums can align with the industry's needs and wants. In the context

of a developing country, statistics show that the construction industry in Vietnam has steadily grown in the last two decades with a development rate of 6.7% and contributes around 6.4% to the nation's GDP [5]. The market demand for infrastructure and building construction with capital investments has increased year by year in the country. Therefore, it is crucial to take advantage of additive technologies such as BIM to improve the construction industry's performance and return on investment. The Vietnamese government agencies and industry stakeholders are aware of the benefits of projects with BIM, so they put a lot of effort to enhance the BIM implementation in the industry. The National BIM roadmap has been developed since 2013 and officially launched in 2015, with the legal framework for BIM projects have been proposed to promote the application of BIM in Vietnam [6]. However, the lack of skilled BIM personnel is one of the main barriers to BIM implementation in Vietnam [7, 8, 9]. Although the educational institutions have introduced various BIM training programs in Vietnam [10], it is necessary to develop an appropriate BIM training model that closely follows the market's needs and requirements. Meanwhile, the essential role of Technical Vocational Education and Training (TVET) is to equip individuals with practical skills, knowledge and attitudes for specific occupations and preparations for higher education [11]. One of the advantages of the TVET's training models is to produce job-ready graduates because the curriculums focus on practical skills and industrial standards [12]. Although there have been increasing numbers of BIM delivery courses in Vietnam, the industry still faces a lack of BIM technicians [13]. Therefore, the Ho Chi Minh City College of Architecture and Construction (the College) developed a BIM technician training model to provide graduates that meet industry standards. This study focuses on developing an institution-industry collaboration model for BIM technician training in a TVET college in Vietnam. The results help to establish and clarify skillsets for BIM technicians toward the actual requirements of the labour market. This study further validates the model by evaluating the performance of the BIM competencies of graduated students to explore the most needed competencies for BIM technicians. These findings draw recommendations for the College to improve the BIM technician training model. Other colleges and universities can benefit from these findings in developing their teaching and training programs for BIM human resources.

2. Literature Review

The rapid development of BIM creates a high demand for experienced BIM professionals in the construction industry market. However, many countries have had a shortage of BIM personnel for years [9, 14, 15]. To meet the industry demand, educational institutions have introduced BIM-related training programs in different modes such as higher education, on-job training, vocational training or professional training [10]. Many researchers reported that BIM education is much more than instructions of software package usage; the more important is introducing the consistency in BIM approach and collaboration between all disciplines involved in a construction project [15, 1]. It is not only about the new system and tools; it is about how people involved can together use the tools and systems efficiently to achieve the common goals.

Several BIM education frameworks have been proposed to accelerate BIM education [16, 17]. However, universities and educational institutions are facing several issues in developing and delivering BIM training programs. In detail, employers often complain that university graduates are impractical or a gap between educational outcomes and industry needs [16]. Jin et al. agreed that educators have not yet realised that BIM education requires industry-oriented curricula [18]. There is also clear evidence that disconnection between curricula and industry requirements leads to graduates' outdated knowledge and employer dissatisfaction [19]. In response to this, a collaborative BIM education framework has been introduced so that industry partners are involved in promoting industry-oriented BIM curricula [20, 21]. The concept of institution-industry collaboration also helps students to gain hands-on experience and understand the industry expectations. Although all parties are aware of the importance of institution-industry

collaboration, how to implement the collaboration framework remains unanswered.

BIM technician is one of the BIM-related professionals. Uhm et al. defined the term of BIM technician according to BIM jobs and competencies based on the use of terms in the industry [3]. BIM technician is a representative job title for some equivalent BIM-related job titles, including BIM modeller, BIM drafter, BIM draftsman, BIM structure/architecture/MEP designer and Revit technician. According to some job searches, the primary tasks of a BIM technician are as below [22]:

- working alongside a team to produce technical drawings that meet clients' requirements;
- using specialist software to produce BIM models and visualisations;
- producing concise 3D models from existing 2D information as required;
- providing design coordination and information;
- finding solutions to technical problems that may arise;
- updating and recording all documents accurately;

Uhm et al. mapped almost 6,000 competency elements extracted from 242 job descriptions to develop a three-level education road-map for eight BIM roles, including BIM technicians [3]. The research shows that the roles and competencies required for each job are different and can be used as a guide to develop a specific BIM training program. Based on the map, most entrants to BIM technician have a relevant technical vocational education with suitable subjects include architecture, construction, civil/structural engineering or architectural technology. Uhm et al. grouped competencies for BIM technicians into essential competency (interacting with computer, establishing interpersonal relationships, etc.), common competency (documenting/recording, understanding compliance, standards, etc.) and job-specific competency (communicating with supervisors and peers, coordinating works and activities with others) with other personal skills such as time management and thinking creatively [3]. This approach provides industry-oriented answers to what to educate and what graduates should be able to perform when completing the BIM technician training program.

3. The case study context

The Ho Chi Minh City of Architecture and Construction College is an institution of vocational training for construction and architecture technicians in Vietnam. The College offers various skill certificate programs, and qualifications including architecture design, interior design, civil engineering, and real estate. The targeted students are those who graduated from secondary and high schools. The training curriculums in the College includes both Institute-Based Training and On-the-Job Training at the workplace of employers under the supervision of senior staff.

The College has developed the BIM training program since 2012 and fully integrated BIM courses into the architecture curriculum since 2015. The College uses the College-Industry collaboration model for BIM training courses with the duration of one year and a half full-time studying at the College and two-month BIM-based project internship at the participating companies. The development of the collaboration program was advised by industrial experts who are hiring BIM technicians in their companies. The College has collaborated with various local and international enterprises to develop and deliver the BIM technician education program for nine years. The training model focuses on the most needed and practical skills to fit with the actual requirements of the labour market and deliver in a reasonable time of education and training.

4. Research Methodology

The study employs a case study approach to evaluate a college-industry collaboration BIM training model in a TVET institution in Vietnam. The case study approach has been widely

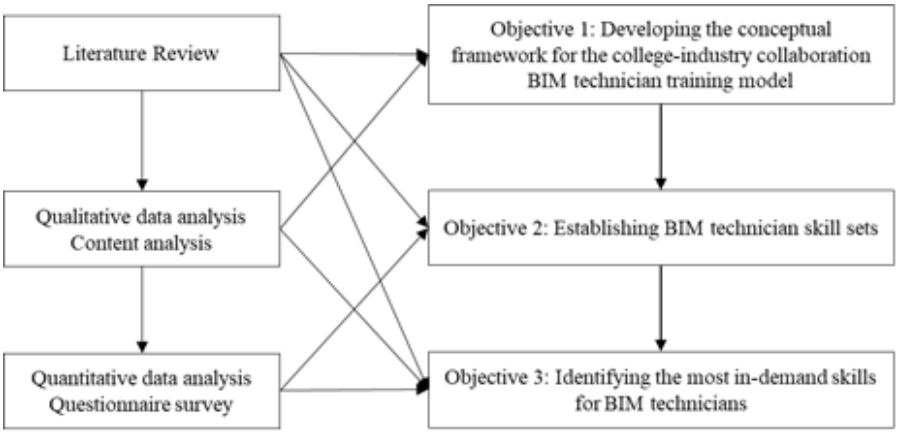

Figure 1. Research design

adopted for contextualised research [23], and it allows researchers to understand better both the particular details and holistic picture of a scenario [24]. Therefore, the case study is suitable for investigating lessons and gaining new practical and scientific knowledge in BIM education in TVET. Two of the authors were involved in the course development and delivery, so they have a depth understanding of the course structure and learning outcomes. The research design was developed as shown in Figure 1.

The literature was searched and reviewed in the first phase to develop a conceptual framework for the college-industry collaboration BIM training model. The model states who the partners are, what to educate, what each party can contribute, and when and how to collaborate. The qualitative phase was conducted with content analysis to investigate skillsets of BIM technicians from the literature review, job searches and in conjunction with consultancy from the partners. Finally, in phase 3, a questionnaire survey was distributed to evaluate the performance of the designed skill sets of graduated students. The survey was distributed in mid-2020 with the participation of 111 graduated students from the College and 20 construction companies who employ the students educated by the program. A descriptive analysis was provided to highlight and demonstrate the most critical skills and expectations from the students and industrial partners' perspectives.

5. Findings and Discussion

5.1. The College-Industry collaboration training model

The aim of the College-Industry collaboration training model is to provide students with a learning environment that simulates the real working environment for a BIM modeler. The model features several steps to answer three questions: what are learning outcomes, what can each party contribute, and how to implement the collaboration to achieve the learning outcomes. The collaboration started with interviewing industrial experts to determine the learning outcomes of the BIM technician program. The main findings include what students should know, what skills are required after completing the program, and how the industrial partners contribute to learning outcomes. Therefore, the BIM technician curricula are realised as industry-oriented curricula with subjects and learning outcomes (LO) illustrated in Table **??**.

After one year and a half of studying background and BIM knowledge at the College, students will take a two-month internship at the industrial partners' companies. During the internship, the College's lecturers and industrial mentors work together closely to support students in achieving learning outcomes. The College's staff schedule their visits to the industrial partners'

office to observe and respond to the students' queries. With support from their lecturers, the students are more confident in performing their tasks and achieving learning outcomes.

The collaboration model benefits all the parties, including the College, students, and industrial partners. The students have opportunities to exposure to real-life projects at a workplace and obtain hands-on experience with BIM software and practices. Experienced mentors at the office act as BIM instructors that help students strengthen their BIM knowledge and collaboration skills. Chen et al. support this view by providing evidence that using actual projects helps students easily understand the roles of different stakeholders, information interoperability and communication in a BIM-based project process [16]. Moreover, the students have a chance to explore the companies' culture and workplace code of conduct so they will be ready to start their careers once they graduate.

Table 1. Learning outcomes for BIM technician program.

Code	Program's outcomes	Subjects offered	Contributor(s)
LO1	Understand the typical principles of engineering design and essential knowledge at TVET	Technical design, Architectural design principles, Architectural structure, Building structure, Quantity take-off	The College
LO2	Understand fundamental knowledge of BIM, including definitions, procedures, and standards	BIM introduction	The College
LO3	Use typical BIM tools and software to create and update BIM models	BIM tools (AutoCAD, 3D Sketchup, Revit Arc/Str/MEP)	The College
LO4	Understand the roles, communication and collaboration in BIM implementation	Design project (Arc/Str/MEP)	The College and Industrial partners
LO5	Take an internship to involve in real-life projects and gain hands-on collaboration experience	BIM internship	The College and Industrial partners
LO6	Recognise the market demands and requires for updating skills to improve career prospects	All subjects	All parties

Like other TVET institutions in Vietnam, the College usually faces limited access to the state budget, preventing them from investing in BIM labs and software. With this model, the College can use the industrial partner's existing resources such as lab facility, BIM tools, industrial standards, and IT systems to apply more interactive pedagogical methods for delivering BIM courses. In addition, after the internship, the College collects reflection reports from the enterprises with information on assessing the students' performance, reviewing the learning outcomes, and sharing suggestions for improvement. Accordingly, the College can update and improve the BIM modeler course to meet the industrial standards. The industrial partners also can gain, directly and indirectly, benefits through their involvement in the program. 20/20 enterprises in this survey recruit the graduated students who are equipped with essential knowledge and skills so that they can save time and effort in training new staff. Secondly,

partnering with the College helps the enterprises present their contributions to the community to enhance their brand image in this field.

The model promises a win-win for both College and industrial parties, but some challenges remain. While the College tends to focus on the comprehensiveness of the acquired knowledge, the industry partners prefer hands-on applications and practical skills. If the model can balance the needs and wants of both parties, it will be a very positive move towards improved BIM education in the College in particular and in TVET in general. The initial achievements show that young people aged 16-18 could become BIM technicians after 18 to 24 months of education and have positive feedback from employers. This model is in line with the fast-growing digital construction in Vietnam and matches the needs and expectations of young people who cannot attend the more extensive education at universities.

5.2. Development of BIM Technician Competencies

According to the findings from the literature and learning outcomes of the BIM technician program, several competencies for BIM technicians were defined. The BIM training program has consultancy of the industrial partners so that the knowledge and skills covered in the program are the most needed for BIM technicians to perform their job and prepare for more extensive education. The competencies include related knowledge and skills that enable the students to complete their BIM-related tasks and perform effectively: fundamental knowledge, BIM knowledge, technological competencies, collaboration competencies, and self-development competencies. The list of the skills is illustrated in Table 2. The relationships among these competencies are hypnotised, as shown in Figure 2.

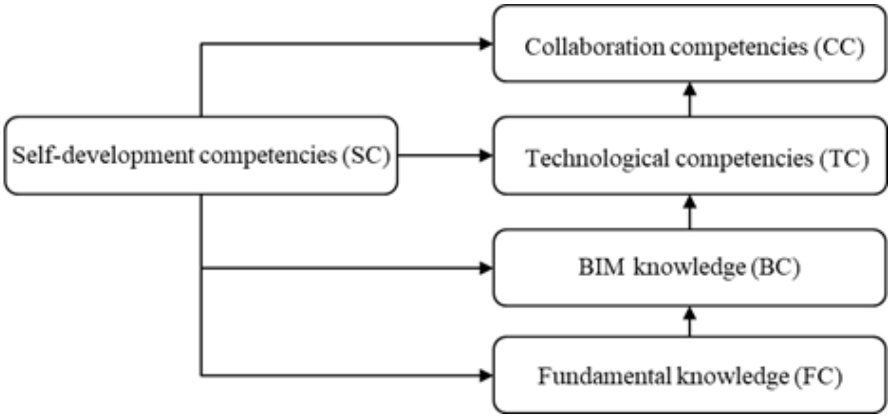

Figure 2. BIM Technician competencies

The competencies are defined to align with the learning outcomes that ensure the students are equipped with essential knowledge and skills to be able to perform the BIM technician job once they graduate. The fundamental knowledge (FC) is a part of LO1, which covers the typical engineering design principles such as drafting, laying out, shop drawing, visualisation, libraries, and families in design (FC1). With LO1, the students are also taught the foundation knowledge of engineering/technology, including architecture, structure, and MEP (FC2). Regarding BIM knowledge (BC), which is covered by LO2, students are equipped with BIM concepts, including definitions, benefits, costs, and trends (BC1). The course also offers typical BIM procedures and standards (BC2) and information management and exchange protocols in BIM (BC3).

Once students are equipped with the fundamental knowledge, BIM-based technological and collaboration skills are introduced in LO3, LO4 and LO5. In terms of technical competencies

(TC), five competencies are focused on the course, which range from basic computer skills to BIM-based software skills shown in Table2. As mentioned, the internship is designed to help students gain communication skills and collaboration experience in a real-life project. Prior to the BIM internship, students have to complete the design project course in Semester 3. The course is a group assignment that offers students a background in teamwork and communication in a design project. Alongside the BIM internship, four communication and collaboration skills are expected that students can perform when finishing the training program.

In Figure 2, the competencies have interrelationships with others, while self-development competencies (SC) are assumed to reflect all competencies. Understandably, SC competencies are parts of LO6 that enable students to update the market demands and improve career prospects. Four personal skills are expected including SC1, SC2, SC3, and SC4. In the condition of rapid development of BIM and the short period of training, the involvement of industrial parties in delivering LO3, LO4 and LO5 strongly support the College in the decision making of what to include in the BIM technician program and what to leave to the student to self-teach for their development (SC4).

Table 2. Learning outcomes for BIM technician program.

Code	Competencies
	Fundamental Knowledge
FC1	Typical engineering design principles such as drafting, laying out, shop drawing, visualisation, libraries, and families in design
FC2	Foundation knowledge of engineering, including architecture, structure, and MEP
	BIM Knowledge
BC1	BIM concepts, including definitions, benefits, costs, and trends
BC2	Typical BIM procedures and standards
BC3	Information management and exchange protocols in BIM
	Technical Competencies
TC1	Interacting with computers and applications (word, excel, PowerPoint, etc.)
TC2	Specialist software proficiency for work (2D and 3D modelling software such as CAD, SketchUp, Revit, ArchiCAD, Allplan)
TC3	Producing models/drawings properly using information instructions/provided
TC4	Coordinating and modifying multi-disciplinary models/drawings
TC5	Documenting and recording to ensure that the documents are accurate and up to date
	Collaboration
CC1	Understand roles and responsibilities of BIM technicians in BIM implementation
CC2	Establishing and maintaining interpersonal relationships at work
CC3	Coordinating works and activities with others in the team
CC4	Liaising with supervisor and peers to achieve the common goal
	Self-development competencies
SC1	Enthusiastic attitude
SC2	Time management
SC3	Be flexible and open to change
SC4	Continuously learning new knowledge and skills for work

5.3. Evaluation of BIM Technician Competencies

Every year, the College collected reflection reports from the industrial partners to assess their overall satisfaction with the student's performance in the internship. In 2020, the College conducted a questionnaire survey targeting both industrial partners and graduated students to collect their responses on the importance of the designed competencies in the BIM program. The survey was sent to emails of the industrial partners and alumni students. After one month, 131 valid responses were recorded. Due to the page limit, only descriptive analysis is discussed in this paper.

Among 131 responses, 111 graduated students work with BIM-related jobs and 20 representatives from enterprises who employ the graduated students. There are 27% of the student participants freshly graduated, which means they have less than one year of experience, 47,7% of graduates have one to three years of experience, and 25.3% have more than three years working in the BIM field. Among 20 industrial representatives, there are three BIM directors, five BIM managers, four BIM team leaders, four BIM senior staff, and four BIM staff. 70% of industrial representatives have more than five years of working with BIM (40% have more than ten years experience). The survey asked the participants to assess the importance of 18 competencies on a scale from 1 (not important) to 5 (absolutely important). The mean scores of 18 competencies are in Figure 3, and the top ten importance are shown in Table 3.

The participants evaluated all 18 competencies are essential for BIM technicians. All mean scores are higher than 3, with 15 out of 18 competencies having mean scores higher than 4 (important) and 3 out of 18 having mean scores between 3 (moderately important) and 4 (important). Interestingly, the highest mean score elements are collaboration competencies (CC) and self-development competencies (SC). Enthusiastic attitude (SC1), time management (SC2), continuously learning new knowledge and skills for work (SC4) are the top three highest mean scores. Understandably, BIM is a new area, and students might find that creating BIM models is complicated at the beginning. Creating, updating, and coordinating information in BIM models requires a lot of time and re-do process, which tends to inhibit their enthusiasm toward the course [25].

Significantly, most of the students enrolled in the BIM training program at the College are young people aged 16-18; therefore, being enthusiastic is the most important for their learning journey. The second highest score is a willingness to learn new knowledge and skills for work (SC). From my perspective, SC4 is important for all professions in our lifelong learning, and it is important for BIM technicians because the two-month internship seems too short to gain hands-on experience. Hence, to become a skilled BIM technician and further education, graduates should keep learning and updating their skills.

SC2, time management, the third-highest score, is supported by other researchers. Uhm et al. investigated 242 BIM-related job descriptions and found that time management is an essential skill required for all BIM roles in the industry [3]. Another element in SC, SC3, is at rank the 7th, so all elements of self-development competencies are evaluated in the top ten important competencies. Similarly, all elements in collaboration competencies (CC) are ranked at 4th, 5th, 6th and 9th in the list. Many researchers agreed that collaboration is an essential competency for BIM-related jobs [14, 16], so BIM technician has no exemption. The other two elements in the list are producing models/drawings properly using information instructions/provided (TC3) and foundation knowledge of engineering/technology, including architecture, structure and MEP (FC2). Based on the findings, effort should continue and expand to provide more opportunities to students to improve their learning outcomes.

6. Conclusions and Further Research

This study reports on a College–Industry collaboration case study for BIM education in Vietnam. Six learning outcomes obtained by delivering institution-based courses and a two-

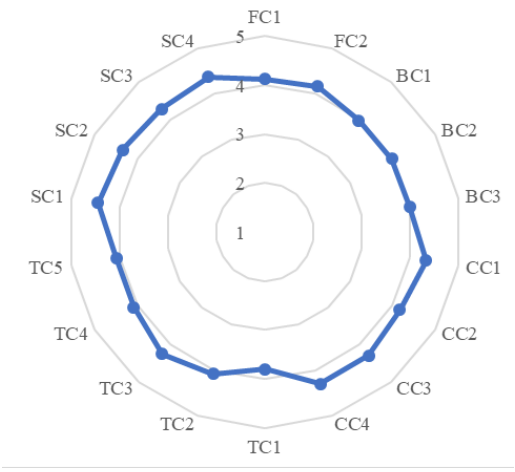

Figure 3. The importance of competencies for BIM technicians

Table 3. Rank of the most ten important competencies.

Code	N	Minimum	Maximum	Mean	Rank
SC1	131	2	5	4.45	1
SC4	131	2	5	4.37	2
SC2	131	2	5	4.35	3
CC1	131	2	5	4.34	4
CC4	131	2	5	4.30	5
CC3	131	2	5	4.30	6
SC3	131	2	5	4.27	7
TC3	131	2	5	4.25	8
CC2	131	2	5	4.18	9
FC2	131	2	5	4.16	10

month internship in the BIM program will enable students to be equipped with theoretical knowledge and practical skills to perform BIM technician related-jobs. The model benefits all parties, which offers students better opportunities to learn about collaboration skills in a real-life project. Participants' feedback indicates that the collaboration and self-development competencies are the most important for BIM technicians providing recommendations for the College to improve the BIM training program. The findings provide a foundation for future research in strengthening the collaborative approach between colleges and industrial partners in developing training programs in educational institutions. By defining the list of essential competencies required for BIM technicians, further research will explore the inter-relationship between the identified skill sets in supporting the learning outcomes and satisfying the labour market's requirements.

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