Article

A Study on the Constructivism Learning Method for BIM/IPD Collaboration Education

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Abstract: The purpose of this study is to verify the effectiveness of the constructivism education theory in building information modeling (BIM)/integrated project delivery (IPD) collaboration education by determining education methods that are most relevant to collaboration in the interaction process. We propose a BIM training model that enhances students' satisfaction in class and collaboration. We aim to identify interrelationships between BIM collaboration education and constructivism theories, examining constructivism methods in BIM/IPD classes to discern which are the most suitable for improving and enhancing collaboration and the proposed education model. A model of the hypothesis "Constructivism Collaboration Process (CCP)" for BIM/IPD collaboration education was derived and a curriculum was created. The hypothesis model was tested by dividing into an experimental group and control group, and finally, prior and post-satisfaction and collaboration level assessments were performed in the BIM and IPD classes. After evaluating and analyzing the improvement in collaboration level and satisfaction, the results were derived for the hypothetical model of the "Constructivism Collaboration Process (CCP)" and the facts that can have a positive impact on BIM/IPD education.

Keywords: social constructivism learning; BIM (building information modeling); IPD (integrated project delivery); flipped learning; role-playing learning; scaffolding learning; PBL (project-based learning); PBL (problem-based learning)

1. Introduction

In the past decade, the Ministry of Land, Infrastructure, and Transport of Korea made efforts to apply building information modeling (BIM) and expand technology to all areas of the construction industry in order to develop construction technology, improve design quality, and efficiently manage construction. Since 2016, the agency has been actively engaged in the movement of each institution, such as mandating the application of BIM for customized services. In terms of BIM technology, various technological research and development has been conducted, including BIM compatibility development, BIM design software development, 4D and 5D collaborative software development, VR/AR and fourth industrial technology convergence, and BIM and GIS combination attempts. However, the level of BIM education to expand the introduction of BIM practices and apply technology is still in the beginning stage. BIM education tends to focus on simple modeling and is viewed as an extension of CAD (Computer Aided Design) education. Rather, software utilization training has become the focus of BIM training, confounding the intrinsic motivation and purpose of the construction industry to introduce BIM. BIM does not simply change from 2D design to 3D visualization, it is a way of collaboration among team members through information management and teamwork [1]. Currently, most of the BIMs are used as educational tools, but what is lacking is a lack of understanding of interdisciplinary collaboration [2]. The essence of BIM practical education is BIM collaborative learning

to create optimal performances with various participants throughout the entire construction process in terms of ordering, planning design, implementation design, construction, and maintenance through BIM-based integrated projects.

Recently, various educational methods for BIM learners have been attempted, but few curricula have utilized a collaborative approach as a learning goal [3]. Academics are realizing the need for technical education using integrated project delivery (IPD) collaboration and BIM design approaches through industry demand and participation [4]. The BIM itself is difficult to use as a framework for collaboration [5] and IPD allows the desirable direction of BIM.
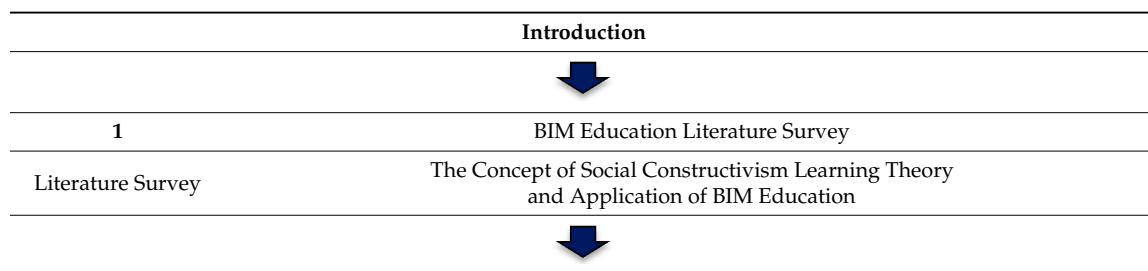
According to Seo Jeong-ho et al. [6], the collaboration in the IPD concept is an important step in improving productivity and eliminating risks between initial design and construction. Collaboration is regarded as one of the essential competencies in education. In addition, education that emphasizes BIM-based collaboration in university is needed, and education design based on the IPD concept of integrating architectural engineering and architectural design is needed [7]. However, practically, BIM/IPD collaborative education has many limitations in terms of learning methods, and thus a new educational approach is needed to improve them.

The purpose of this study is to use the constructivism education theory to confirm the effectiveness of constructivism education theories in BIM/IPD collaborative education, in order to propose a constructivism collaborative process education hypothesis that has the most significant causal relationship with the collaboration in the learning interaction process. In addition, this study aims to evaluate the level of satisfaction and of collaboration after undergoing the proposed training.

2. Research Procedure and Methods

The first step was to research the domestic and international BIM education trends, constructivism learning methods, and constructivism learning theory applied BIM education in the literature. Step two was to apply constructivism education theory to BIM design classes. An experiment was designed to investigate the satisfaction of constructivism (Flipped Learning, Project-based Learning, Problem-based Learning, and Role-Playing) for BIM collaboration. After the experiment design, the experiment was conducted to confirm the causal relationship between constructivism learning theories of BIM collaboration, for which a multiple regression analysis and evaluation of collaboration satisfaction were used. Based on the experiment, the model of constructivism learning theory that affected collaboration was developed. In the third step, according to the experiment results, a model for the "Constructivism Collaboration Process (CCP)" hypothesis for BIM/IPD collaboration education was derived. In step four, curriculum and collaborative education for BIM/IPD collaborative education was designed. In step five, the educational experiments for BIM/IPD classes were examined. It was divided into an experimental group and a control group to test the hypothesis model in the constructivism collaboration process. Lastly, step six was designed for a pre- and post-collaborative satisfaction evaluation of the educational experiments on BIM and IPD classes. After evaluating and analyzing the improvement of the level of collaboration, the results for the hypothesis model of the constructivism collaboration process were derived (See Table 1).

Table 1. Research procedure and composition.

Introduction	
⬇	
1	BIM Education Literature Survey
Literature Survey	The Concept of Social Constructivism Learning Theory and Application of BIM Education
⬇	

Table 1. *Cont.*

	Introduction	
2	BIM Collaboration Education Experiment with Constructivism Education theory	
Experiment BIM Collaboration	Analysis tools methods	1. Satisfaction survey (Keller's ARCS)
		2. Correlation Analysis & Multiple Regression Analysis
	⬇	
3 Hypothesis Model	Hypothesis Model of "CCP" For BIM/IPD Collaboration Education	
	⬇	
4 Experiment Design	Design BIM/IPD Education Curriculum	
	⬇	
5 Experiment	Comparative experiment Implementation (Experimental group and Control group)	
	⬇	
6 Analytical Tool	1. Training Satisfaction Survey 2. Collaboration Level Measurement Survey	
	⬇	
Conclusion	Verification of BIM/IPD Educational Effectiveness on the "CCP"	

3. Theoretical Considerations

3.1. BIM/IPD Education Trend

3.1.1. BIM-Based Architectural Design Education Direction

BIM is a concept that integrates and manages all information that can occur during the entire life cycle of the building, from planning to maintenance [8]. It can be defined as a construction automation system that integrates design and construction during the overall process.

The definition of BIM education means such a design integration as BIM design, BIM practice, and digital technology [9]. Currently, the BIM concept is introduced into the conventional design studio in college, and BIM application elements are attempted in class [10]. The process of deriving design results using BIM software in the studio course is regarded as a BIM design method, and it has been proposed to utilize this method for the BIM function in the design studio [11].

In general, students are highly interested in the design using BIM [10]. As a digital education tool, BIM (Revit) has functions such as high expressiveness, retouch-ability, and connectivity, and spatial perception, 2D-3D linkage, and integrated information management. CAD and Revit can be linked to improve educational efficiency [12]. In addition, BIM education can be applied as a method for integrating various data from architectural, structural, and environmental sources [13]. From a collaboration perspective, moreover, BIM-focused studios can lead to more reliable outputs than normal studios. With BIM, there are also greater opportunities for more active collaboration among students in design studios [13].

In the direction of BIM-based architectural design education, it is desirable to use BIM as a digital education tool to manage the life cycle integration process throughout the whole journey of building design-construction-maintenance, and to integrate and collaborate with other systems.

3.1.2. BIM-Based Engineering Design Education Direction

When BIM is applied to architectural engineering design, it could be leveraged as a way of engineering education in various aspects. Similar to the drawing function in BIM design, alternatives can be derived by using linked analysis software. In addition, the combination of engineering design and BIM can be a useful tool in acquiring architectural knowledge simultaneously [14].

The direction of BIM education in engineering design is to integrate and analyze the elements of engineering education, such as structure, construction, and MEP (Mechanical, Electrical, and Plumbing). In this process, it is necessary to create a curriculum that simultaneously enables both technical and engineering education. At this time, using BIM can help with engineering design collaboration. In order to improve the education process of architectural engineering, it is necessary to comprehensively design and collaborate using 3D models that employ BIM tools. To optimize this, an engineering-based BIM understanding of design, structure, construction, and MEP must be achieved [15].

When BIM is used for education, it is efficient in design education in regards to architectural engineering, 3D-oriented information model education, and BIM tool automatic calculation function [16]. This could also provide the opportunity to collaborate with other engineering departments.

3.1.3. BIM-Based IPD Education

According to the "Integrated Project Delivery: A GUIDE," issued by AIA (American Institute of Architecture) [17], IPD is a method in which a client, architect, contractor, and consultant comprised a team to perform a project and share performance. This was defined as a way to reduce unnecessary work and integrate participants, systems, and business work.

Since BIM provides predictable risks and information in the construction, BIM and IPD should be discussed together [18]. Separation of department education systems between architectural design and engineering is not appropriate in the convergence era, because it reduces competitiveness. Now, IPD collaboration training is needed [7]. The collaboration has been emphasized in architectural and engineering design, and an integrated project linking project-based architecture and architectural engineering classes should be conducted [19]. Collaboration in BIM can be considered as an interaction among participants through the use of construction technology information and software. However, students who do not have practical experience lack the knowledge of design and engineering integration, as well as a technical understanding of BIM, making it very difficult for them to participate in BIM-based IPD collaborative education. Therefore, it is necessary to review and define the educational design of a BIM-based IPD Project suitable for the instructor and student level. It is also necessary to have a proper understanding of BIM projects and technologies. The team members should have practical BIM skill sets. In addition, it is necessary to examine the direction of appropriate learning methods.

3.1.4. Trends in Overseas BIM/IPD Collaboration Training

Woo, Jeong-Han introduced experimental and exemplary BIM education methods and types of collaboration applied in an architectural engineering school in the USA [20].

First, a five-year BIM track was held in the Department of Architectural Engineering and the Department of CM at the MOSE School in Wisconsin. Students would be familiarized with BIM concepts and functions in grades 1 and 2, BIM analysis programs in grades 3 and 4, and Design-Build classes in grades 4 and 5. The higher the grade, the more it aimed for project and collaboration classes.

Second, Texas A&M conducts a process-based BIM education in which construction was conducted in a capstone method (a method in which companies and students jointly carry out projects). The goal was to naturally acquire practical competency by participating together in a class with practitioners.

Third, at the University of Virginia (Virginia Tech) and the University of Southern California (USC), an Integrated Design Build method was applied to conduct an IPD collaboration class that integrates design and construction. To build a team with other schools, an online course was opened to

conduct a cooperative construction management course for BIM. In terms of construction management, it was a good example of collaboration using BIM.

In the United States, BIM collaborative education is taking the form of education that focuses on students' collaboration and practice as they progress to higher grades. In particular, working-level staff participated in the project to be carried out with the students, and an interdisciplinary collaboration team was formed to carry out the project for collaboration with design and engineering.

3.1.5. BIM/IPD Education Direction

For the IPD collaborative education, an author conducted a prior study on class composition, tool method, and curriculum (See Table 2).

Table 2. Literature survey for integrated project delivery (IPD) class.

President Study	Curriculum	Topic	Team Member
[21]	Use 2D/3D/4D/5D program	Atypical project application example	Owner Architect Contractor
	Virtual construction and real construction integration		
	Productivity decline, Project delay, quality problems, difficulty resolving conflicts of interest between participants		
	Sharing and collaborating continuously		
[22]	Conflict and issue experience	Project to improve energy performance	CM Architect MEP Engineers
	Easy to use BIM, promote collaboration		
	Re-use of information		
	Improving productivity and decision-making efficiency		
[23]	Collaboration and information management	Atypical project application example	CM Architect Contractor
	Organizational roles and the importance of collaboration		
	Re-use and exchange of information		
	Using the BIM model as a medium		
	Using a single information model and a combined information model		

In an IPD study [21], the researchers used 2D, 3D, 4D, and 5D programs. By integrating virtual construction and actual construction, they continued to share information and collaborate. Through this process, productivity, delay of schedule, and quality problems were solved in advance. They proposed that the atypical project should be done with an IPD-based approach by forming a team of clients, architects, and contractors.

Lee Seo-Young introduced the concept of IPD and BIM in the project to improve energy performance by 10% [22]. The team was divided into CM (owner, client), architect, and MEP engineer. Through the class, she attempted to experiment on whether students obtained experienced the project conflicts and issues during collaboration, whether they could improve collaboration skills using BIM, whether information could be re-used, and whether productivity and decision-making efficiency could be improved. The lack of unstructured information and knowledge (practical competency and expertise) in IPD classes created difficulties in decision-making. She also noted that incomplete interoperability and re-use of information were not effective.

Jong-Sung Won (2008) observed that collaboration and management of the information are important factors in IPD [23]. He proposed a single information model for the initial stage in the project and a union information model for the large-scale project as a way of management in re-use and information sharing. The team structure was divided into CM, architect, and contractor.

According to the results of the IPD precedent research, the BIM/IPD class composition requires the selection of a project that could compare the degree of improvement and clarity of the team structure and role. He also mentioned that it was necessary to select software that could collaborate with BIM-based 2D, 3D, 4D, and 5D. In addition, information sharing and compatibility could solve various problems between software, which became an important factor in IPD-based education. Therefore,

the definitions of the items required for IPD class composition for BIM/IPD education were organized as follows (See Table 3).

Table 3. Configuration items for IPD collaboration curriculum.

Required Items for IPD Classes	1.	Team	Participants' roles must be defined
	2.	Project	To improve results; Choosing the right project
	3.	Software	Select 2D/3D/4D/5D program suitable for the project
	4.	Problem	Present improvement directions such as design problems, constructability problems, productivity problems, project delay problems, and quality problems
	5.	Project Information	Creation and sharing of project information suitable for the purpose of the project
	6.	Collaboration Method	Define how participants will collaborate

3.2. Social Constructivism Education

3.2.1. Vygotsky's Method of Social Constructivism Learning Method

The constructivism perspective can be seen as differentiated from the theory of epistemology, not the theory of learning, in that it is about interpretation and construction rather than objective knowledge. Per the constructivist method, learning is not a forced injection of objective knowledge but an active process of developing meaning through experience. These theories can influence constructivist educational design.

In the process of questioning and answering each other, the transfer of knowledge and experience of experts and colleagues occurs, thus enabling cooperative learning. As subjects of learning, learners change and develop their knowledge through continuous interaction with the surrounding environment. Constructivism Learning methods include Flipped Learning, Role-Playing Learning, Scaffolding Learning, Project-based Learning, and Problem-based Learning.

Flipped Learning is a method in which a pedagogical approach directs instruction from the group learning space to the individual learning space, and the resulting group pace is transformed into a dynamic, interactive learning environment in which the educator guides students as they apply concepts and engage creatively in the subject matter. The relationship between the instructor and the learner, who was in the upper and lower relationship, means learning in a horizontal structure and complementary two-way dynamic [20]. The advantage of Flipped Learning is that planning for pre-class learning must be preceded and there must be a systematic and organic relationship between pre-class learning and activities to be conducted in class. So, the classroom activity extends beyond the classroom and becomes a team-based learning activity rather than an individual-based one.

Role-Playing Learning is a method rooted in theatrical concepts of actors performing in theater performances. When an individual occupies a role, it is defined according to the social context in which the role is required and the performance function required by the location. Roles, as participants, describe the purpose of a role in social interaction. For participants, the role's characteristics, expectations, and needs and skills must be defined.

Scaffolding Learning is a method in which experts and participants provide individualized support by incrementally improving a learner's ability to build on prior knowledge. Within education, the social learning theory of Vygotsky is generally credited with providing a theoretical basis for the practice, where he describes the ZPD (Zone of Proximal Development). With the help of experts and people around, students can go from the actual development level to the near development level and potential development level. In other words, the role of experts or colleagues is important for this teaching method. An example of this is a child being able to walk with the help of his dad to reach a

level of potential development through the proximity development area. At this time, social interaction takes place, and which develops collaboration skill sets and it can be an important educational factor.

Project-based Learning is a method in which students gain knowledge and skills by working for an extended period of time to investigate and respond to an authentic, engaging, and complex question, problem, or challenge.

Problem-based Learning is a method in which an instructor presents a problem to a learner and collects, organizes, and uses data to solve the problem, which is a voluntary approach to learning beyond the traditional lecture-based learning method and vertical structure of knowledge transfer. It is a method intended to foster innovative talents with creativity, thinking ability, and judgment ability with autonomous will.

3.2.2. Constructivism Learning Method and BIM Education

Abdirad and Dossick claimed that junior-level students should learn the BIM concepts and skills, whereas senior students should learn "collaboration" and "integrated education" [24]. Adamu and Thorpe proposed that students learn via a self-guided video or web-based video, and that they watch a commercial video to learn the technical aspects of BIM software [25]. In addition, it was suggested to combine the Problem-based Learning method with the video course to improve its educational value. In other words, for BIM technical education, active use of video media and project-based classes were conducted, and it was set to resemble the actual situation as much as possible. Jin et al., proposed that not only BIM technology but also collaboration experience was necessary [26]. Therefore, they proposed a scenario that allowed multidisciplinary and interdisciplinary students to work in teams on a project and senior-level college students to form a single team for collaborative effort. Badinrath et al., suggested that educational institutions find ways to share educational resources as much as possible for professors and students [27]. In addition, it was proposed to improve collaboration capabilities and attempt a practical approach through Project-based Learning. Students actively participated in collaboration through projects with clear objectives such as "dismantling design" [28] or "green project" [29]. Shelbourn et al., proposed an instructional scaffolding learning education method for motivation [30]. He aimed to introduce a learning environment that provided numerous resources and aid at the beginning of the project, thereby incentivizing students to participate more in class.

Based on these various constructivism learning application examples, there were five theories applicable to BIM/IPD collaboration in the learning interaction process: Flipped Learning, Role-Playing Learning, Scaffolding Learning, Project-based Learning, and Problem-based Learning. Based on this, the advantages of constructivism education theory for BIM/IPD education at each education level were developed, as shown in Figure 1.
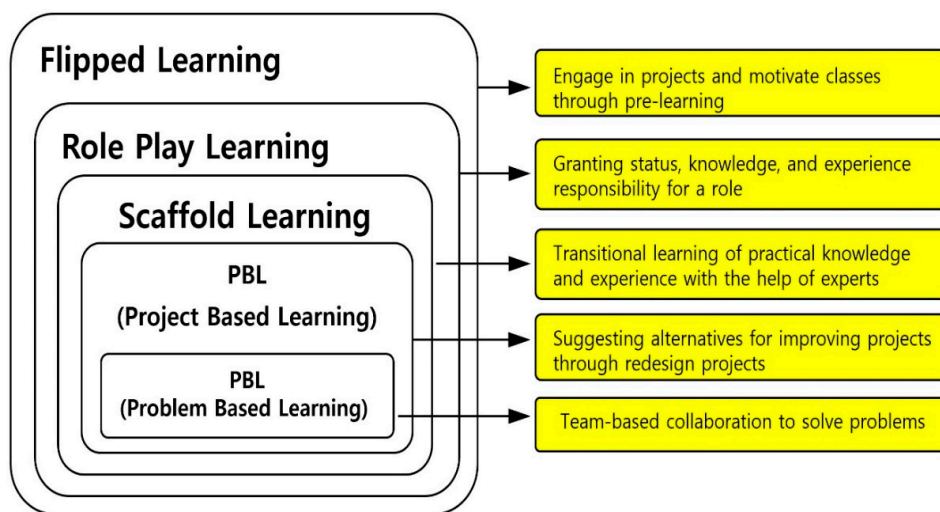

Figure 1. Social Constructivism Theories' composition and advantages.

3.3. Constructivism Learning Hypothesis Experiment to Test BIM Collaboration

In the educational experiment, a multiple regression analysis was performed. This was to measure the satisfaction of the constructivism learning theory and to measure factors that had a significant relationship with constructivism learning theories for BIM collaboration.

The educational experiment was conducted by K University students in the 4th grade (10 teams of 3 students; 30 students). In conducting the remodeling project based on BIM conversion design in the "BIM Design" course, students were given the roles of "Design", "Engineering", and "CM", and were provided missions and guidelines. In addition, students were asked to propose a "5% reduction in volume" plan by simultaneously using Constructivism Learning Theories in terms of Flipped Learning, Role-Playing Learning, Project-Based Learning, and Problem-Based Learning, as shown in Figure 2.
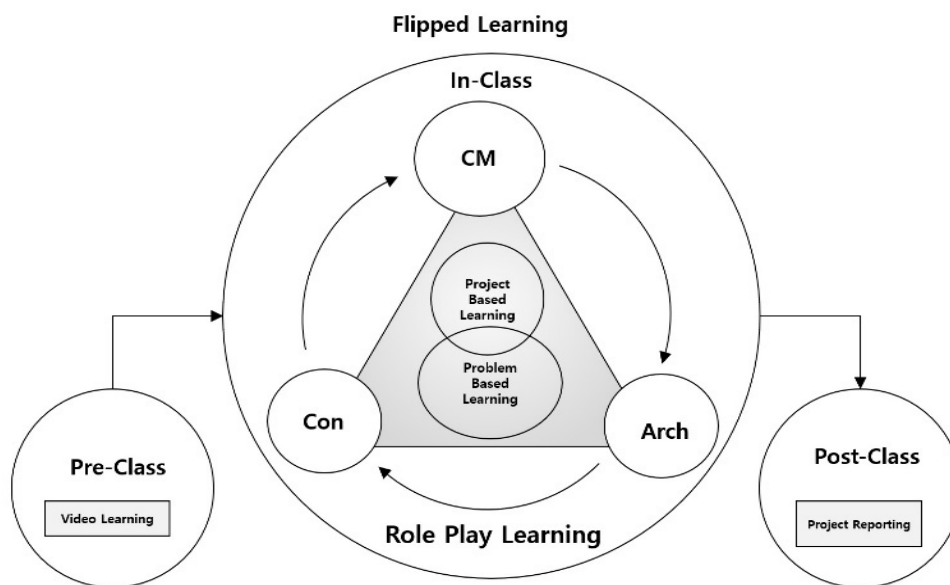
Figure 2. Hypothesis model of "Constructivism Education Theory (CCP)" for building information modeling (BIM) collaboration.

To measure satisfaction, Keller's ARCS training motivation question was used [28]. In order to examine the difference between the satisfaction level of the experiment (out of 5) and the pre/post score, a T-test based on the corresponding sample was conducted. As a result of comparing the average values of the results, "attention" (2.7→3.6), "relevance" (2.3→3.0), "confidence" (2.7→3.0), and "satisfaction" (3.2→3.3) improved. However, in terms of the satisfaction factor, minor changes were observed. Afterward, a Focus Group Interview (FGI) was performed, and according to the results of FGI, technical problems were satisfied through collaboration, but satisfaction in regard to practical problem solving was not improved.

The second correlation measurement aimed to identify the educational methods that affect the educational factors that have the most significant relationship with collaboration among the constructivism education theories. For collaboration, a Pearson correlation analysis was conducted on the measurement variables. Pre-and Post-Class Feedback learning stage (r = 0.687, $p < 0.001$), In-Class and In-Class Feedback (r = 0.663, $p < 0.001$), the Role-Playing learning method (r = 0.697, $p < 0.001$), Project-Based Learning (r = 0.677, $p < 0.001$), and collaboration were found to have a positive correlation. As a result of performing a multiple regression analysis by the stepwise method, the Role-Playing Learning method ($p = 0.003$) showed the greatest influence on collaboration, where the stronger the Role-Playing Learning method (= 0.485), the higher the collaboration. In addition, when In-Class and In-Class Feedback ($p = 0.009 < 0.05$) were higher (= 0.417), the collaboration was higher as well.

Clear role definition, project continuity in class, and feedback appeared to be factors that enhance the strength of collaboration.

In other words, among the constructivism education theories, the most influential method of education was Role-Playing learning, and the most significant relationship with collaboration was the clear definition of role, continuity of project within class, and feedback.

4. Research Method

4.1. Constructivism Collaboration Process (CCP)' Model for BIM/IPD Education

Based on the results of the Educational Experiments, an improved "CCP" model was created, as shown in Figure 3. The "CCP" involves deriving collaborative education experiences and results that can reach the BIM/IPD (Integrated Project Delivery) level.
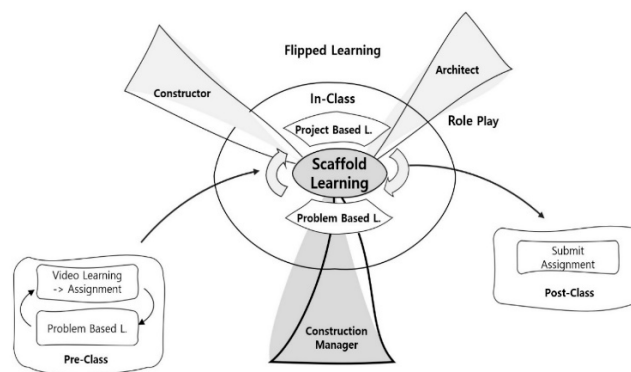
Figure 3. Hypothetical model of "Constructivism Collaboration Process" for BIM/IPD collaboration.

First, the "CCP" emphasizes Pre-Class in Flipped Learning to induce self-directed learning, as well as the feedback relationship between In-Class and In-Class to induce motivation and interest for collaboration.

Second, according to the results of the previous experiment, the demand for collaboration increased as team members' demands for project roles and responsibilities increased. This was a factor that strengthened the collaboration between In-Class and In-Class Feedback in Flipped Learning. Therefore, this hypothetical model was designed to strengthen the need for collaboration by defining and distinguishing clear roles and tasks such as "architectural design", "construction", and "construction management".

Third, in the educational experiment, attention, relevance, and confidence in collaboration improved, but satisfaction did not improve due to the lack of practical roles and responses of team members. Since the importance of a participant's practical knowledge and experience affects collaboration satisfaction, a "scaffold learning method" was applied to induce the transfer of team members' practical skills and experiences through collaborative participation of practitioners (see Figure 3).

Fourth, in order to improve the existing BIM education, an experiment was conducted to make a conversion design in view of Project-based Learning. As a result, it was found that team members highlighted practical problems and focused on efforts to solve problems. Based on this, the Project-based Learning method was integrated into the "constructivism collaboration process".

BIM and IPD can be integrated to approach collaboration through the "constructivism collaboration process,", and the educational hypothesis shown in Figure 4 was established.
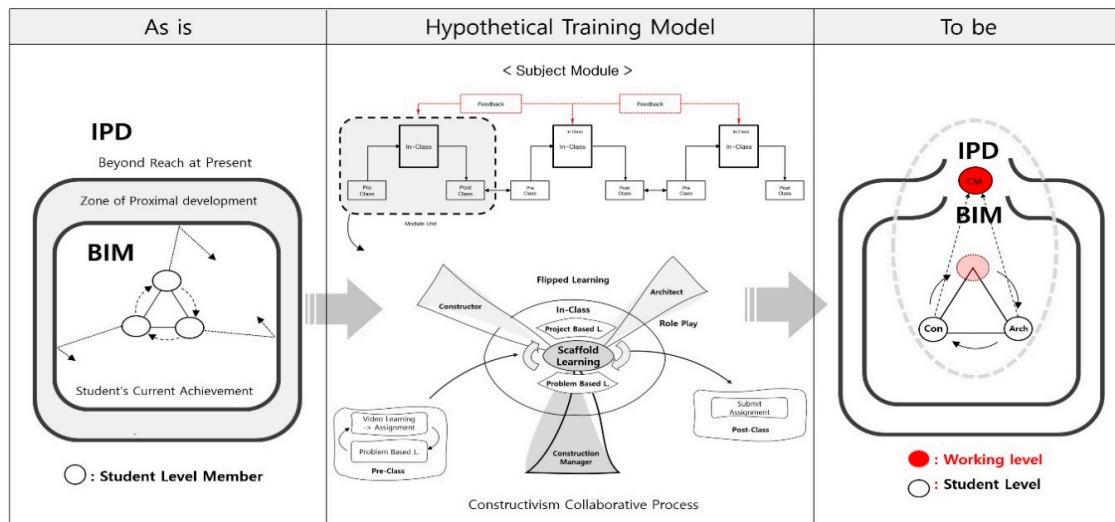
Figure 4. "CCP" model to improve BIM/IPD collaboration training.

4.2. BIM and IPD Collaboration Education Experiment and Curriculum Composition

Composition of Educational Experiments for BIM/IPD Class

A Focus Group Interview (FGI) survey was conducted using the items shown in Table 4, which were derived through the literature review and previous research survey process. Based on this, BIM/IPD education curriculum items were organized, and the composition of curriculum is as follows.

Table 4. BIM collaborative education lab overview.

	"CCP" Education Experiment		
Object	Experimental group (6 days)	Control Group (6 days)	
Qualification	3 years or more practice/ BIM Practical Course Completion	3 years or more practice/ BIM Practical Course Completion	
	15 people (5 teams) 2 students + 1 practitioner	15 people (5 teams) 2 students + 1 practitioner	
Program	Constructivism Collaboration Process	BUILD Smart Association BIM Coordinator Course	
Project	Design and construction improvement plan for "police station"		
Goal	Evaluate and verify "Constructivism Collaboration Process" method in BIM/IPD class.		
Measurement	Collaboration level Survey	Survey (see preliminary survey)	
		1. Joint Decision-Making	2. Administrative Role
		3. Autonomy	4. Mutual Relationship
		5. Trust	6. Collaboration Results
	Collaborative Education Motivation Survey	Survey (recognition survey) See Keller's ARCS questionnaire [31]	
		1. Attention	2. Relevance
		3. Confidence	4. Satisfaction

In regard to the FGI, it was performed on 2 November and 6 November 2019, and 8 experts were invited: 5 BIM education experts, 2 architects, and 1 technical engineer. The subject and contents of the program are given in Tables 5 and 6.

Table 5. Program goals and topics.

Session	Goal	Topic	Contents
1 (6 h)	Understanding the project	Drawing understanding BIM template	Understanding project drawings; Deriving drawing problems
2 (6 h)	Build Modeling	Collaboration	Drawing-based project modeling; Collaboration
3 (6 h)	Consistency Review	Collaboration Consistency Review	Drawing-based project modeling; Organizing and fixing collaborative/ drawing errors
4 (6 h)	Alternative; Error	Modeling modifications	Design and construction review
5 (6 h)	Alternatives; Quantity calculation	Quantity calculation	Design modification/ construction feasibility review
6 (6 h)	Alternatives; Process Management	Process Management	Quantity Calculation/ Process management improvement

In the first session, pre-class training was conducted with the theme of "understanding of drawings and BIM templates", and the goal was to make students understand the project. To this end, students were supposed to grasp the project contents and analyze the drawings to derive problems independently. In the second session, with the goal of project modeling, students worked together to build 3D BIM Modeling with 2D drawing. In the 3rd session, the aim was to review the drawing errors. Students were subjected to conduct a "co-consistency review jointly", which had them build 3D BIM Modeling together and list up the drawing errors. In the 4th round, students focused on "modifying modeling" and aimed to suggest alternatives to fix errors. By conducting design and construction reviews together, students were able to identify unexpected issues and proposed their own alternatives to fix these errors. In the 5th round, the theme was "quantity calculation" and aimed to "improve quantity calculation". By conducting design and construction reviews together, students were able to present their own improvement plan. Lastly, in the 6th round, the main theme was "Process Management," which aimed at "Deriving Alternative Process Management". Students presented their own process management alternatives by carrying out the quantity calculation and process management together.

Table 6. Constructivism collaboration process training program.

Role Theory	Role Status	CM Manager			Architect			Constructor		
	Role Expectation	Total Ordering, General Manager			Design, Design Manager			Construction Responsibility, CM Responsibility		
	Role Request	Schedule Management/Design Management Construction Management/Cost Management			Design/Modeling Finishing Planning/Quantity Preparation			Process Planning/Quantity calculation Construction Method/Construction Cost		
	Class Classification	Pre-Class	In-Class	Post-Class	Pre-Class	In-Class	Post-Class	Pre-Class	In-Class	Post-Class
Flipped Learning	Preparation	Project contents/schedule/results/drawing distribution								
	Module 1 Understanding the project Design analysis	dwg distribution/Create template	Collab.	Error Report	dwg distribution Create template	Collab.	Error Report	dwg distribution Create template	Collab.	Const. Review
	Module 2 Project Arch./Structure Modeling	Collab. method	Collab.	Error Report	Collab. method	Collab.	Error Report	Collab. method	Collab.	Const. Review
	Module 3 Modeling analysis/ Const. analysis/ Collabo.	Collab. method	Collab.	Quantity cal.	Collab. method	Collab.	Design modeling	Collab. method	Collab.	Review of provisional facilities
	Module 4 Modeling analysis Const. analysis Error report	Modeling/ Vol. Cal.	Collab.	Quantity Improvement	Modeling/ Volume Cal	Collab.	Design Improvement	Modeling Vol. Cal.	Collab.	Const. Improvement
	Module 5 Design/Process Improvement of quantity/Const.	Navis-works/Process Mgmt.	Collab.	Process creation	Provide drawing/video	Collab.	Design Improvement	Provide process Mgmt. video	Collab.	Method improvement, Quality Improvement
	Module 6 Design/Process Volume/ Improvement of Const	Navis-works/Process Mgmt.	Collab.	Process Improvement	Provide drawing/video	Collab.	Design Improvement	Provide process Mgmt. video	Collab.	Method improvement, Quality Improvement

4.3. BIM/IPD Collaborative Education Experiment

4.3.1. Study Subjects and Experiment Procedures

The CCP training method aimed at in this study comprised of Flipped Learning, Role-Playing Learning, Project-Based Learning, Problem-Based Learning, and education using the Scaffolding Learning method, which is hereinafter defined as constructivism education. Based on this, in order to understand the effect of the project program on the level of collaboration and the incentive to cooperate in education, the research subjects were selected, as shown in Table 7.

Table 7. Research Target Selection.

Classification	Members	# Of ppl/Group	Assistant
Experimental Group	15	3	5 groups
Control Group	15	3	5 groups
Total	30	30/10	10 groups

A total of 30 groups, including 15 experimental groups and 15 control groups, were selected. Each group consisted of 3 persons, and there were a total of 10 groups of 5 groups. In addition, the procedures for applying the "constructivism education-based collaboration project" program and measuring the dependent variables conducted in this study were organized, as shown in Table 8 below.

Table 8. Experiment procedure.

Classification	Pre-Measures	Program Application	Post-Measure
Experimental Group	O	O	O
Control Group	O	Building Smart Association BIM Coordinator Course	O

Surveys were conducted twice, before and after the experiment, on the experiment and control groups. The dependent variables were "Collaboration-Level Survey" and "Collaboration Education Motivation Survey". The "Constructivism Education-based Collaboration Project" program was applied only to the experimental group, and the "BIM Coordinator" program was applied to the control group.

4.3.2. Composition of Dependent Variables

In this study, in order to measure the dependent variables that are changed by the "CCP" program, a collaboration-level survey and collaborative training motivation survey were selected. The structure is shown in Tables 9 and 10.

4.4. Analysis Tools and Methods

4.4.1. Collaborative Education Motivation Investigation

The structure of the "collaborative education incentive" item to be measured in this study was Keller's ARCS [28], which consists of 19 items, as shown in Table 9; it includes 4 items on the satisfaction factor, 7 items on the attention factor, 4 items on the relevance factor, and 4 items on the Self-Confidence factor. These items are on the Likert 5-point scale, and the higher the score, the higher the "collaborative motivation" for each factor. For this, the Focus Group Interview was conducted.

Table 9. Training Satisfaction Questionnaire for collaborative motivation.

	Item Contents **Keller's ARCS Survey Reference [31]**
Satisfaction (4)	1. I was satisfied with a collaboration class for BIM/IPD.
	2. I would like to take this class at the next opportunity.
	3. I think this teaching method has improved BIM and practical knowledge.
	4. I am satisfied that a learning method has improved BIM collaboration skills.
Attention (7)	5. I like to teach my team members
	6. I think a learning method helped to participate and learn BIM collaboration.
	7. I actively prepared for pre-class assignments and In-class activities.
	8. I like various ways of learning such as Self-directed Learning.
	9. The teaching project topic provided by the instructor were sufficient to reach the goal of the collaborative class.
	10. The learning method was effective in improving BIM collaboration skills over existing BIM classes.
	11. I actively participated in collaboration through this class.
Relevance (4)	12. Everything in this class meets the purpose of a collaborative class.
	13. I think the level of BIM/IPD collaboration class was appropriate for collaboration.
	14. I think the selected project was appropriate for the purpose of the class and the relevance of collaboration.
	15. I was appropriately involved in various Self-learning activities during the class.
Self-Confidence (4)	16. I would like to recommend this collaboration process to another person.
	17. I fully understand a collaboration class.
	18. I think the purpose of this class has improved my BIM skills and my ability to collaborate.
	19. I gained confidence in BIM and collaboration through this class.

4.4.2. Collaboration Level Survey

The measurement of the level of collaboration was based on the five cores of collaboration by Thomson et al. [29] and added "Items for department collaboration results." The five key categories are (1) Joint Decision-Making; (2) Administration; (3) Organizational Autonomy; (4) Mutuality; and (5) Trust. Based on the five major categories of collaboration by Thomson et al. [32], the Focus Group Interview survey was conducted over two days, November 22 and 23 of 2019, to form the second sub-category item and question. There were 10 experts including 1 professor, 5 BIM education experts, 2 architects, 1 technician, and 1 BIM consultant. The structure of the items was as shown in Table 10 below. The measurement tool for collaboration level consisted of 22 items, including 3 items for decision factors, 3 for administrative role factors, 3 for autonomy factors, 5 for correlation factors, 3 for trust factors, and 5 for collaboration outcome factors. In addition, the feasibility was secured through the preliminary investigation process. The items were based on a 5-point Likert scale, where the higher the score, the higher the level of collaboration for each factor.

4.4.3. Analysis Process

The constructivism-based project program presented in this study was intended to grasp the effect of the level of collaboration and incentives for collaborative education. Based on the data collected through this process, the following analysis procedure was conducted.

First, the Cronbach's α value was investigated to determine the level of collaboration, which was the dependent variable of this study and the reliability of the composition of educational motivation.

This value was for grasping the internal consistency, and when it was 0.6 or more, the reliability between items was high.

Second, an independent sample T-test was conducted to understand the homogeneity of the "collaboration level" and "pre-score for inducing education motivation" of the experimental and control groups selected in this study. When there was a significant difference between the groups in this analysis, the composition of the group was adjusted. When adjustment was not possible, a prior score was input as a covariate and then ANOVA was performed.

Table 10. Training satisfaction questionnaire for the level of collaboration.

Factor (Number of Questions)	Item Details (Refer to Preliminary Survey)
Joint decision-making (3)	1. Team members often discuss videos and project issues they saw before class.
	2. Team members take each other's opinions seriously and discuss them when it becomes a decision-making situation during class.
	3. After class, team members organize each other's decisions. And I will take the video and project of the next class and take it seriously.
Administrative Role (3)	4. Team members understand each other's roles and responsibilities as a collaborative member.
	5. Team members perform the necessary functions to facilitate collaboration.
	6. Team members have a good share of our team's collaboration goals.
Autonomy (3)	7. Classes facilitate the achievement of our team mission.
	8. Our team is influenced by the roles of its members.
	9. I strive to meet the expectations of our team and the expectations of collaboration.
Mutual Relationship (5)	10. Partner team members and teams work together to ensure that the benefits of collaboration extend to everyone.
	11. Our team shares information with partner team members to enhance our work and programs.
	12. I feel that our team is recognized and respected by team members during the collaboration process.
	13. Our team believes that working with team members can achieve a better goal than working alone.
	14. Our team and team members work together to motivate each other.
Trust (3)	15. I can trust members who participate in collaboration.
	16. Our team often relies on partner members for collaboration.
	17. Our team feels that it is more valuable to work and maintain efforts with partner members than to quit collaboration.
Collaboration Result (5)	18. Overall, collaboration is effective in achieving expected goals and outcomes.
	19. Overall, as a result of collaboration, the quality of work we have done with our team and members is high.
	20. Overall, we have expanded our collaboration on current issues or issues compared to the transfer of members of our team.
	21. Overall, as a result of collaboration, the interaction of teams and team members (such as collaborative work and consultation) has increased.
	22. Overall, collaboration helped members influence equalize each other.

Third, a 2 × 2 mixed variance analysis was conducted to determine whether the constructivism-based project program proposed in this study affected the level of collaboration and motivation to educate students. Through this analysis, it was possible to determine whether the effect of the constructivism-based project program on the level of collaboration and motivation to induce education was a group effect, an effect depending on the input time, or an interaction effect between the group and the timing.

Fourth, for the experimental group to which the constructivism-based project program was applied, a corresponding sample T-test was conducted to determine whether a significant change occurred between the pre- and post-scores.

Fifth, a counter-sample T-test was conducted to determine whether a significant change occurred between the pre- and post-scores of the control group to which the general project program was applied.

Sixth, a T-test of the corresponding sample between the experimental group and the control group was conducted for the post-score of cooperation level and motivation for education. This was to determine if there was a difference in the effect of applying the constructivism-based project program and the general project program.

Seventh, for the above analysis, the level of collaboration and the normality of educational motivation scores were grasped. When normality was not secured, the T-test was replaced by a Wilcoxon test, and the variance analysis was replaced by a Kruskal–Wallis test. The regularity test was done in two steps. When normality was secured in more than one of the two stages, it was assumed that there was normality. First, to check the normality of univariate, skew and kurtosis values were investigated. Normality was assumed when skewness was derived as absolute value 2 and kurtosis was less than absolute value 7. Second, a Shapiro–Wilk test was performed to determine the statistical significance of normality. In this test, normality was assumed when the probability of significance was $p > 0.05$.

5. Analysis

5.1. Analysis of Educational Motivation

The "Constructivism Collaboration Process" is an educational hypothesis model composed of constructivism learning theory in terms of Flipped Learning, Role-Playing learning, Scaffolding learning, Project-based Learning, and Problem-based Learning. The "Constructivism Collaboration Process" hypothesis model was experimented on in two groups: in the experimental group, the "BIM/IPD collaborative training course" was applied, and the "BIM coordinator course "by the Building Smart Association was applied on the control group.

In regards to the "inducing motivation," both the experimental group (See Table 11) and control group (See Table 12) are increased in the (1) satisfaction (See Figure 5) on the collaboration, (2) attention (See Figure 6) on the collaboration, and (3) adequacy (See Figure 7) on the collaboration. However, in regards to (4) the self-confidence (See Figure 8) factor, the experimental group showed that the post-score was higher than the pre-score, and the control group showed that the self-confidence was decreased.

Table 11. Analysis result of difference between pre- and post-scoring incentives of Experimental control group.

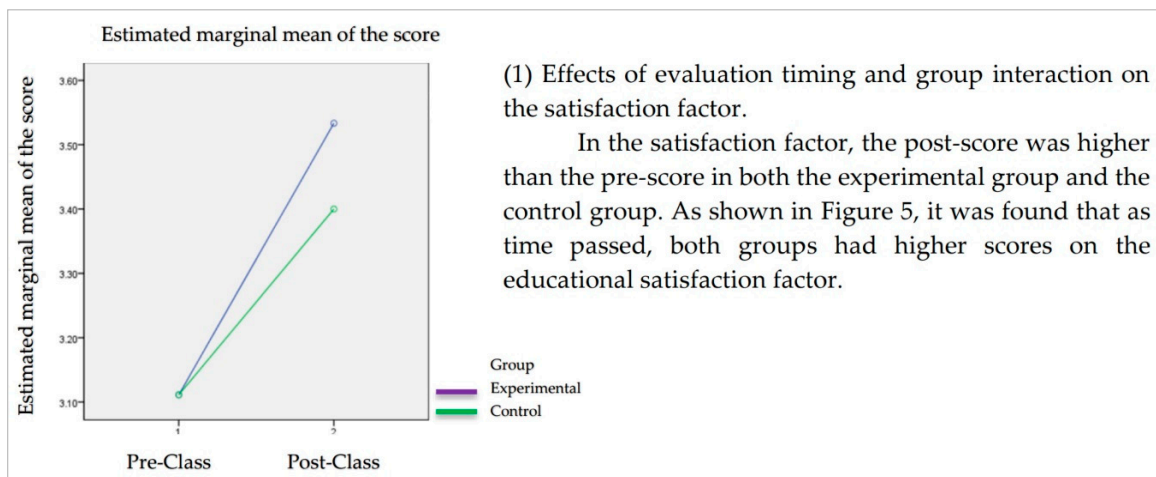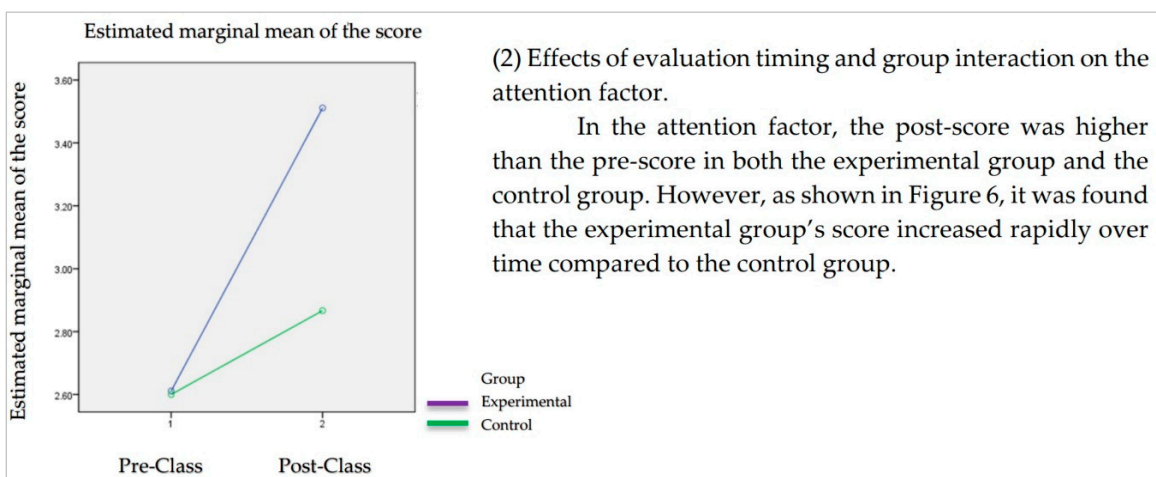| Factor	Time	M	N	SD	T	P
(1) Satisfaction	Pre	3.111	15	0.626	−2.391	0.031 *
	Post	3.533	15	0.501		
(2) Attention	Pre	2.611	15	0.381	−7.475	0.000 ***
	Post	3.511	15	0.256		
(3) Adequacy	Pre	2.283	15	0.499	−6.644	0.000 ***
	Post	3.017	15	0.395		
(4) Confidence	Pre	2.707	15	0.291	−7.513	0.000 ***
	Post	3.373	15	0.328		

*: P < 0.05, ***: P < 0.001.

Table 12. Analysis result of difference between pre- and post-scoring incentives of control group.

Factor	Time	M	N	SD	T	P
(1) Satisfaction	Pre	3.111	15	0.663	−1.326	0.206
	Post	3.400	15	0.566		
(2) Attention	Pre	2.600	15	0.326	−2.300	0.037 *
	Post	2.867	15	0.352		
(3) Adequacy	Pre	2.400	15	0.611	2.882	0.012 *
	Post	2.700	15	0.493		
(4) Confidence	Pre	2.760	15	0.508	0.960	0.353
	Post	2.627	15	0.291		

*: $P < 0.05$.

(1) Effects of evaluation timing and group interaction on the satisfaction factor.

In the satisfaction factor, the post-score was higher than the pre-score in both the experimental group and the control group. As shown in Figure 5, it was found that as time passed, both groups had higher scores on the educational satisfaction factor.

Figure 5. Effect of timing and group interaction on Satisfaction.

(2) Effects of evaluation timing and group interaction on the attention factor.

In the attention factor, the post-score was higher than the pre-score in both the experimental group and the control group. However, as shown in Figure 6, it was found that the experimental group's score increased rapidly over time compared to the control group.

Figure 6. Effect of timing and group interaction on Attention.

(3) Effects of evaluation timing and group interaction on the adequacy factor.

　　In the adequacy factor, both the experimental group and the control group had a higher post-score than pre-score. However, as shown in Figure 7, it was found that the experimental group's score increased rapidly over time compared to the control group.
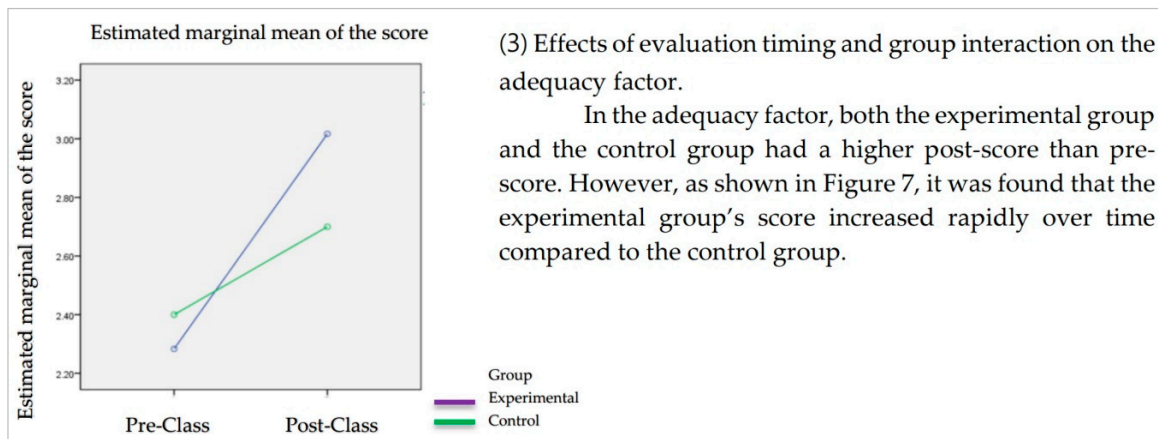
Figure 7. Effect of timing and group interaction on Adequacy.

(4) Effects of timing and group interaction on self-confidence factor.

　　In the self-confidence factor, the post score of the experimental group was higher than the pre-score. In contrast, the control group had a higher pre-score than post-score. As shown in Figure 8, as time passed, the score of the experimental group increased, whereas the control group's score decreased.
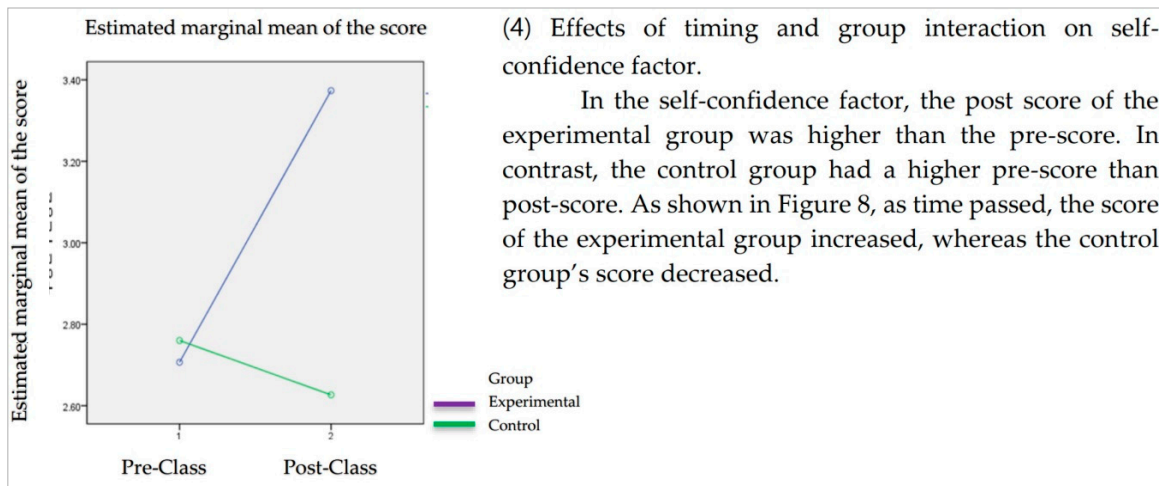
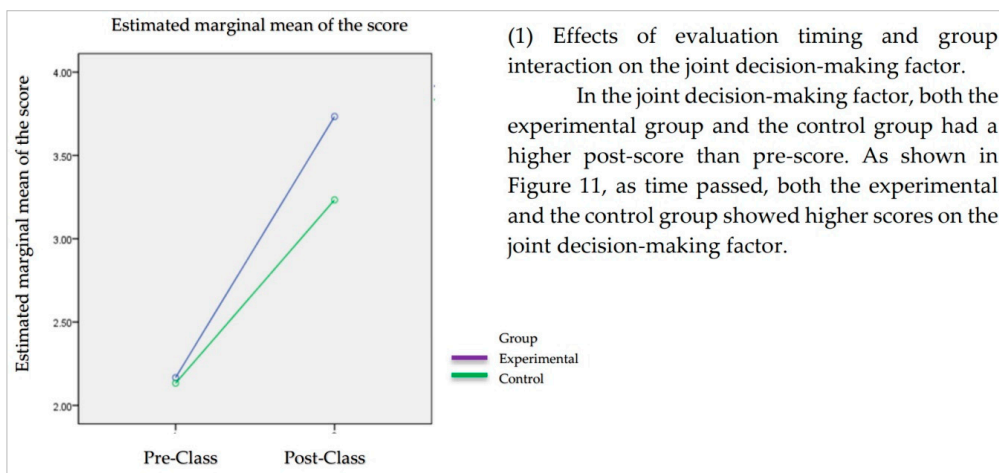**Figure 8.** Effect of timing and group interaction on Confidence.

5.2. Results of Analysis of Differences Between Groups of Collaborative Post-Scores

　　In regards to the "Measurement of Collaboration Level," the experimental group (See Table 13) increased in the (1) joint decision-making (See Figure 9), (2) administrative role (See Figure 10), (3) autonomy (See Figure 11), (4) mutual relations (See Figure 12), (5) trust (See Figure 13), and (6) collaboration results (See Figure 14). On the other hand, the control group increased in the post-scores of (1) joint decision-making on cooperation (See Figure 9) and (5) trust (See Figure 13). However, the control group (See Table 14) had no changes in the (3) autonomy (See Figure 11), (4) mutual relationship (See Figure 12), and (6) collaboration results (See Figure 14). Rather, the post-score for the administrative role (See Figure 10) of collaboration decreased—that is, the level of collaboration decreased.
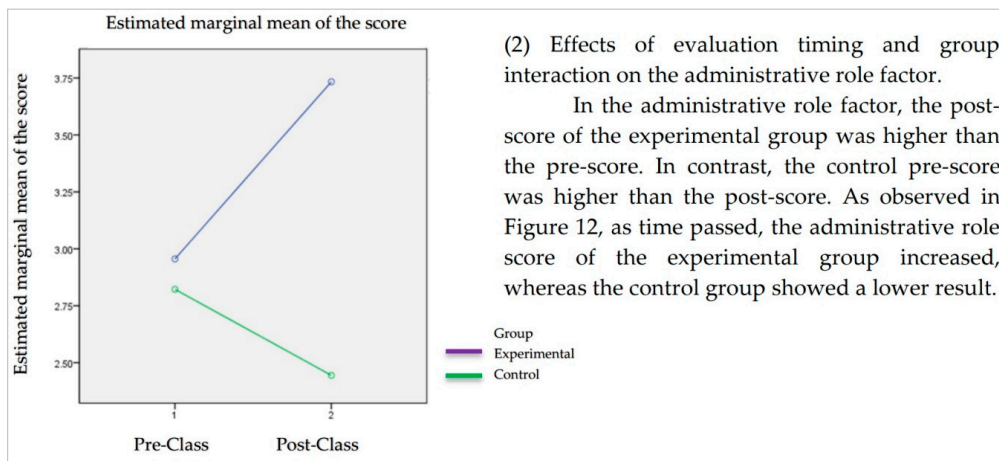
Table 13. Analysis result of difference between pre- and post-scores in the collaboration level of the experimental group.

	Factor	Time	M	N	SD	T	P
(1)	Joint Decision-Making	Pre	2.167	15	0.699	−7.029	0.000 ***
		Post	3.733	15	0.372		
(2)	Administrative role	Pre	2.956	15	0.434	−3.949	0.001 **
		Post	3.733	15	0.580		
(3)	Autonomy	Pre	2.133	15	0.339	−12.551	0.000 ***
		Post	3.617	15	0.452		
(4)	Mutual Relationship	Pre	2.760	15	0.442	−6.517	0.000 ***
		Post	3.467	15	0.464		
(5)	Trust	Pre	2.467	15	0.399	−4.583	0.000 ***
		Post	2.967	15	0.352		
(6)	Collaboration Result	Pre	2.573	15	0.320	−7.261	0.000 ***
		Post	3.560	15	0.304		

**: $P < 0.01$, ***: $P < 0.001$.

(1) Effects of evaluation timing and group interaction on the joint decision-making factor.

In the joint decision-making factor, both the experimental group and the control group had a higher post-score than pre-score. As shown in Figure 11, as time passed, both the experimental and the control group showed higher scores on the joint decision-making factor.

Figure 9. Effect of timing and group interaction on Joint Decision-Making.

(2) Effects of evaluation timing and group interaction on the administrative role factor.

In the administrative role factor, the post-score of the experimental group was higher than the pre-score. In contrast, the control pre-score was higher than the post-score. As observed in Figure 12, as time passed, the administrative role score of the experimental group increased, whereas the control group showed a lower result.
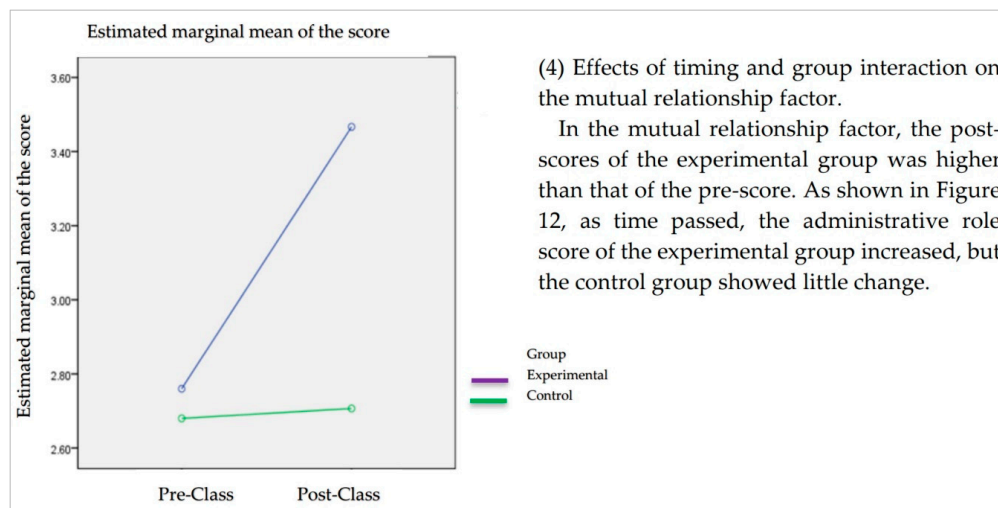
Figure 10. Effect of timing and group interaction on Administrative Role.
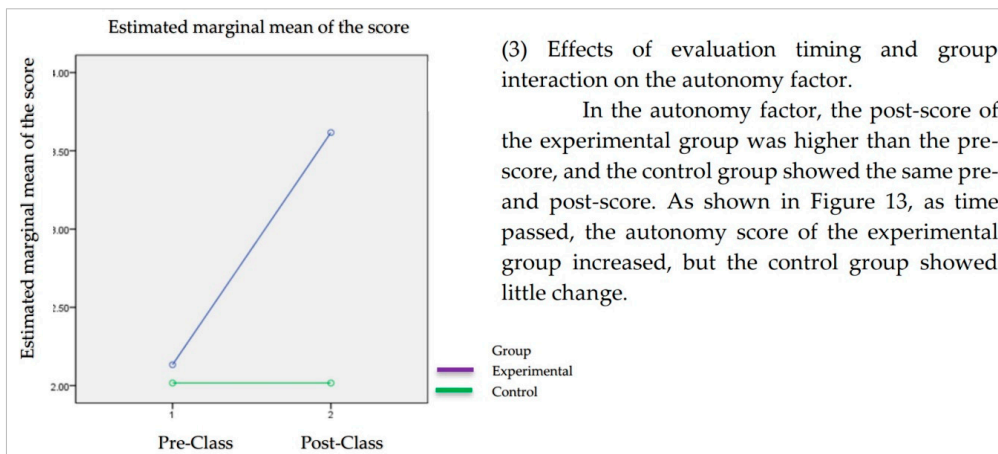
(3) Effects of evaluation timing and group interaction on the autonomy factor.

In the autonomy factor, the post-score of the experimental group was higher than the pre-score, and the control group showed the same pre- and post-score. As shown in Figure 13, as time passed, the autonomy score of the experimental group increased, but the control group showed little change.
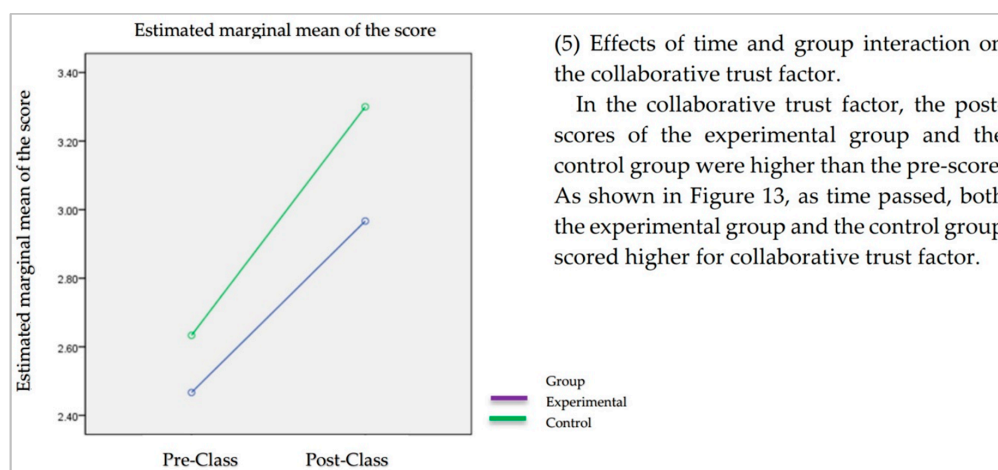
Figure 11. Effect of timing and group interaction on Autonomy.

(4) Effects of timing and group interaction on the mutual relationship factor.

In the mutual relationship factor, the post-scores of the experimental group was higher than that of the pre-score. As shown in Figure 12, as time passed, the administrative role score of the experimental group increased, but the control group showed little change.

Figure 12. Effect of timing and group interaction on Mutual Relationship.

(5) Effects of time and group interaction on the collaborative trust factor.

In the collaborative trust factor, the post-scores of the experimental group and the control group were higher than the pre-score. As shown in Figure 13, as time passed, both the experimental group and the control group scored higher for collaborative trust factor.

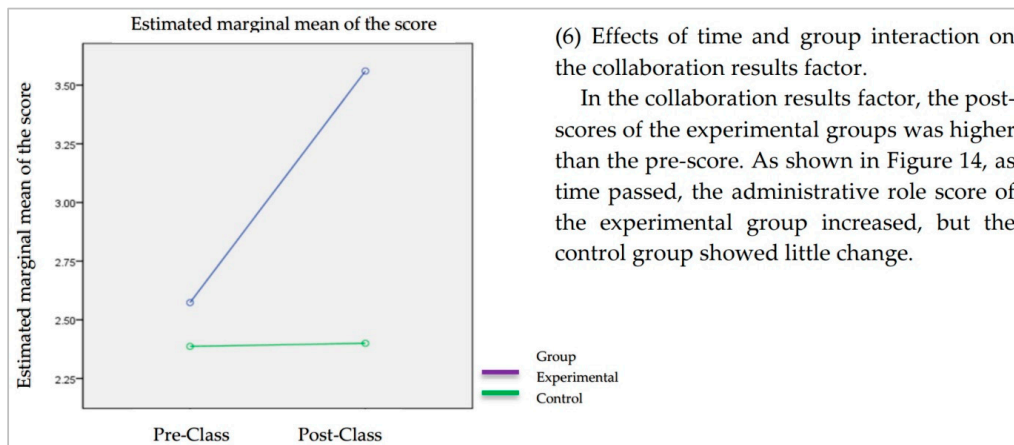**Figure 13.** Effect of timing and group interaction on Trust.

(6) Effects of time and group interaction on the collaboration results factor.

In the collaboration results factor, the post-scores of the experimental groups was higher than the pre-score. As shown in Figure 14, as time passed, the administrative role score of the experimental group increased, but the control group showed little change.

Figure 14. Effect of timing and group interaction on Collaboration.

Table 14. Analysis result of difference between pre- and post-scores of the control group's collaboration level.

	Factor	Time	M	N	SD	T	P
(1)	Joint Decision-Making	Pre	2.133	15	0.550	−4.680	0.000 ***
		Post	3.233	15	0.623		
(2)	Administrative Role	Pre	2.822	15	0.502	3.697	0.002 **
		Post	2.444	15	0.325		
(3)	Autonomy	Pre	2.0167	15	0.372	-	-
		Post	2.0167	15	0.372		
(4)	Mutual Relationship	Pre	2.680	15	0.517	−0.619	0.546
		Post	2.707	15	0.433		
(5)	Trust	Pre	2.633	15	0.352	−5.292	0.000 ***
		Post	3.300	15	0.316		
(6)	Collaboration Result	Pre	2.387	15	0.366	−0.112	0.913
		Post	2.400	15	0.214		

**: $P < 0.01$, ***: $P < 0.001$.

6. Conclusions

"Constructivism Collaboration Process (CCP)" is an educational hypothesis model consisting of constructivism learning theory in terms of Flipped Learning, Role-Playing Learning, Scaffolding Learning, Project-based Learning, and Problem-based Learning. The hypothesis model of "Constructivism Collaboration Process" was divided into experimental and control groups. BIM/IPD collaborative training course was tested in the experimental group and 'BIM coordinator course' was tested in the control group.
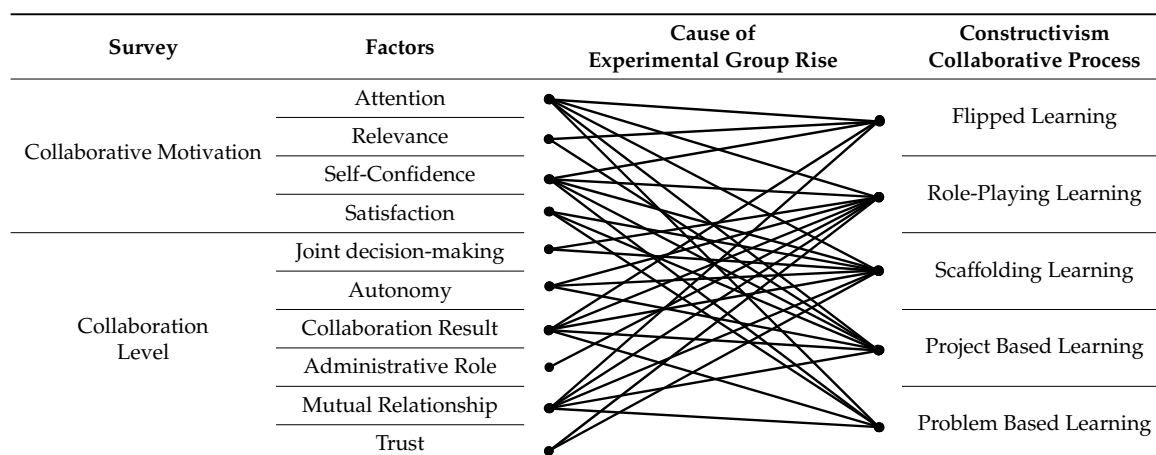
According to the results of the hypothesis experiment of the "CCP", the experimental group in the 'Collaborative Motivation' survey increased by 26 percent on average and the control group rose by 7 percent. In the "Collaboration Level" survey, the experimental group improved the average collaboration level by 42 percent and the control group rose by 10 percent (See Table 15). In addition, it was necessary to figure out an effective constructivism education method for improving educational quality and collaboration. Therefore, a Focused Group Interview (FGI) was conducted for 10 team leaders who participated in the experimental group. The results are shown.

Table 15. Pre-score and post-score improvement rates of collaboration between experimental and control groups.

Factors		Improvement Rate	
		Experimental Group	**Control Group.**
Collaborative Motivation	Attention	35%	10%
	Relevance	32%	13%
	Self-Confidence	24%	−5%
	Satisfaction	14%	19%
	Average rate of rise	**26%**	**7%**
Collaboration Level	Joint decision-making	72%	52%
	Autonomy	69%	0%
	Collaboration Result	38%	1%
	Administrative Role	26%	−15%
	Mutual Relationship	25%	1%
	Trust	20%	25%
	Average rate of rise	**42%**	**10%**

In the 'Collaborative Motivation' survey, the experimental group (1) increased collaboration 'Attention' by 35 percent, (2) increased collaboration 'Relevance' by 32 percent, (3) increased collaboration 'Self-Confidence' by 24 percent, (4) increased collaboration 'Satisfaction by 14 percent. According to the FGI analysis of the team leader in the experimental group, 'Attention' and 'Self-Confidence' were influenced by "CCP (Holistic constructivism method)", 'Relevance' was Flipped Learning and Project-based Learning was affected. In the Pre-Class phase, video lectures on BIM technology were applied to Flipped Learning, which influenced the class activities, attention, and relevance of In-Class. The Project-based Learning method aimed at improving performance improved students' knowledge motivation and learning level relevance. In addition, 'Satisfaction' was influenced by Scaffolding Learning, Project-based Learning and Problem-based Learning (See Table 16).

Table 16. An analysis of effective constructivism training methods for collaboration.

Survey	Factors	Cause of Experimental Group Rise	Constructivism Collaborative Process
Collaborative Motivation	Attention		Flipped Learning
	Relevance		
	Self-Confidence		Role-Playing Learning
	Satisfaction		
Collaboration Level	Joint decision-making		Scaffolding Learning
	Autonomy		
	Collaboration Result		Project Based Learning
	Administrative Role		
	Mutual Relationship		Problem Based Learning
	Trust		

When applying Scaffold Learning, students were able to solve technical questions by asking each other. Especially, when the team leader solved practical problems through Scaffold Learning, students were most satisfied, and when applying Project-based Learning to solve the problem, students' satisfaction increased.

In the 'Collaboration Level' survey, the experimental group (1) increased "Joint decision-making" by 72 percent, (2) increased 'Autonomy' by 69 percent, (3) increased 'Collaboration results' by 38 percent (4) increased 'Administrative role' by 26 percent, (5) increased 'Mutual relationship' by 25 percent, (6) increased 'Trust' by 20 percent. According to the FGI analysis of the team leader of the experimental group, in the question of collaboration level, 'Collaboration Results' and 'Interrelationship' were influenced by "Constructivism Collaborative Process (Holistic constructivism method)". 'Joint decision making (72 percent)' was influenced by Role-Playing Learning and Scaffold Learning. Technical problems arising from the video lessons were solved through Role-Playing Learning, and practical problems arising from the project were understood and solved through the team leader's Scaffold Learning. 'Autonomy' was influenced by Role-Playing Learning, Scaffold Learning, and Project-based Learning (PBL).

In order to achieve the goal of improving project performance, the problems given to roles were improved practically. 'Administrative role (26 percent)' was influenced by Role-Playing Learning. When students fulfilled the goals of collaboration, team member responsibilities, and required functions according to defined roles, they were able to reach the target.

'Trust (20 percent)' was influenced by Role-Playing Learning and Scaffold Learning. 'Trust' was improved by exchanging and teaching thoughts and knowledge according to roles. Role-Playing Learning gave expectations about the role, status and performance of team members. This expectation had a direct effect on 'Joint decision-making', 'Autonomy', 'Administrative role', and 'Trust', which in turn contributed to raising the 'Collaboration Level' (See Table 16).

As a result of comparing the pre- and post-application scores of the "CCP" applied to the experimental group, the 'Collaborative Motivation' and 'Collaboration Level' scores improved overall. Therefore, it has been found that the "CCP" and 'Constructivism theory' can have a positive effect on BIM/IPD collaboration training.

Specifically, the "CCP" was much more effective in raising the 'Collaboration Level' than 'Collaborative Motivation'. "CCP" improved 'Attention' and 'Self-Confidence' in 'Collaborative Motivation' compared to the control group, and 'Collaboration Level' improved 'Collaboration Result' and 'Correlation'. As the individual learning method, the most effective learning for 'Collaborative Motivation' was 'Flipped Learning' and 'Scaffold Learning', and the most effective learning for 'Collaboration Level' was 'Role-Playing Learning'.

Limitations and Future Research

Recently, the BIM/IPD ordering method has been gradually applied in the construction industry, and the need for BIM-based collaboration capabilities has been increased. As a result, the importance of BIM collaborative education has also been recognized in the industry and schools as an essential factor for the improvement. Therefore, research and experiments on various constructivism education methods are needed to improve the level of BIM/IPD collaborative education further in depth.

The "CCP" could be a way to train BIM/IPD collaboration in response to the industry needs. However, the constructivism learning-based collaboration process would vary per diversity of the project, the goals and objectives of the collaboration, the propensity of the participants, and the given training time. Therefore, in order to maximize the effectiveness of individual constructivism learning theories and educational experiments on BIM/IPD collaboration, a variety of studies are needed to improve the satisfaction of certain educational theories. In addition, research on the collaborative measurement indicators will be needed to measure the degree of improvement in satisfaction and collaboration level in BIM/IPD education.

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