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BIM and E-Negotiation Practices in AEC Consulting Businesses

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Abstract: Architectural, engineering, and construction (AEC) consulting businesses are developing into a specialized industry, and collaborative decision making is essential to obtain the finest design. Everything is now virtual. Building information modelling (BIM) has the most potential to support current practices. BIM is promising for effective and efficient design processes. Negotiation and decision-making processes appear to be activities that are the most difficult for BIM to facilitate. Both activities are hard to complete in person and virtually. Every participant has their own preferences, intention, and pay-off optimum, and conflicts are difficult to avoid. Communication and e-negotiation are main issues in BIM practices. This paper proposes BIM and e-negotiation practices in AEC consulting businesses, with the main intention to reveal critical success factors that enhance the utilization of BIM in supporting communication and e-negotiation. A survey through observation and questionnaire distribution was used to collect the data. Descriptive analysis through a mean and standard deviation scatter plot was used to analyse the data. Two hundred and two respondents consisting of 91 design managers (leaders) and 111 designers/consultants (non-leaders) were involved in the research. Based on the analysis, it was found that there are different perceptions between those two groups. The design managers stated that they were the most vital factor in supporting the e-negotiation in BIM, whereas the consultants (designers) stated that job description was the main essential factor.

Keywords: e-negotiation; BIM; collaborative design; construction project management

1. Introduction

Information and Communication Technology (ICT) has many advantages for the business process, as it supports communication between two or more parties. In line with ICT development, the business process has simultaneously developed. ICT has broken the time and place boundaries of the business process, especially that of collaboration in architectural, engineering, and construction (AEC) consulting. Communication is an important ingredient for negotiation success [1]. Negotiation in AEC not only involves talking about business. It is also used to find best-fit options in deciding design alternatives within the design or planning phases in construction projects. Various consultants are needed, and building complexity makes their collaboration necessary. Negotiation and decision making are two main activities in this collaboration and lead to the production or development of an integrated and fine design that satisfies requirements.

Business collaboration can also be found in the project development of commercial properties. It concurrently occurs since many consulting firms (architecture, construction management, interior design consulting, structural consulting, quantity surveying, etc.) can, thus, easily produce a fine design of commercial properties. Communication is the basic foundation for the collaboration of these firms [2]. The negotiation process is also a major factor in collaboration success in terms of achieving the finest design. Thus, building information modelling (BIM) has become vital for the design process as well as the sustainability of their business. BIM is needed to support the work and businesses. During the design process as well as during collaboration with another party, each firm needs to negotiate design aspects (aesthetics, strength, function, construction ability, operability, etc.) to be able to achieve the finest design of commercial properties. Negotiation becomes essential in BIM. Previous studies have developed the e-negotiation model for collaboration practices in the design process [3,4], but research on negotiation in BIM is rare. The developments of e-negotiation in virtual collaboration include automated negotiation, a virtual design studio [3], knowledge management for decision support, and a shared workspace [4].

E-negotiation is also being used and developed by AEC consulting firms in Indonesia. This paper reports an empirical study of e-negotiation practices in the collaboration of design projects, particularly exploring e-negotiation facilities and communication support in the implementation of BIM for developing commercial properties. The study began with a preliminary study of grounded theory through a literature review, observation, and a survey to develop the theoretical framework. The study then continued with the distribution of surveys and questionnaires, with 202 respondents with experience in e-negotiation and the application of BIM. The results were analysed using a scatter plot of mean and standard deviation scores. A case study of the e-negotiation process among design consultants was also conducted to verify the analysis. This study will theoretically support the computer supported collaborative design (CSCD) research development as well as empirically develop BIM programs and e-negotiation practices in the design process.

2. Grounded Theory

2.1. Preliminary Study and Literature Review on the Design Process

A preliminary study was conducted by implementing grounded theory based on a literature review, observation, and surveys with the main purpose of developing a conceptual model of research. Previous studies related to e-collaboration and e-negotiation between consultants in the design process were reviewed to determine the most relevant factors. The review was also conducted to illustrate research development and its future direction. The mapping for previous research is presented in Figure 1. Based on the research methodology used, previous studies can be classified into four main categories: literature reviews, case studies, modelling, and applied IT. These papers were then sorted based on their publication year.

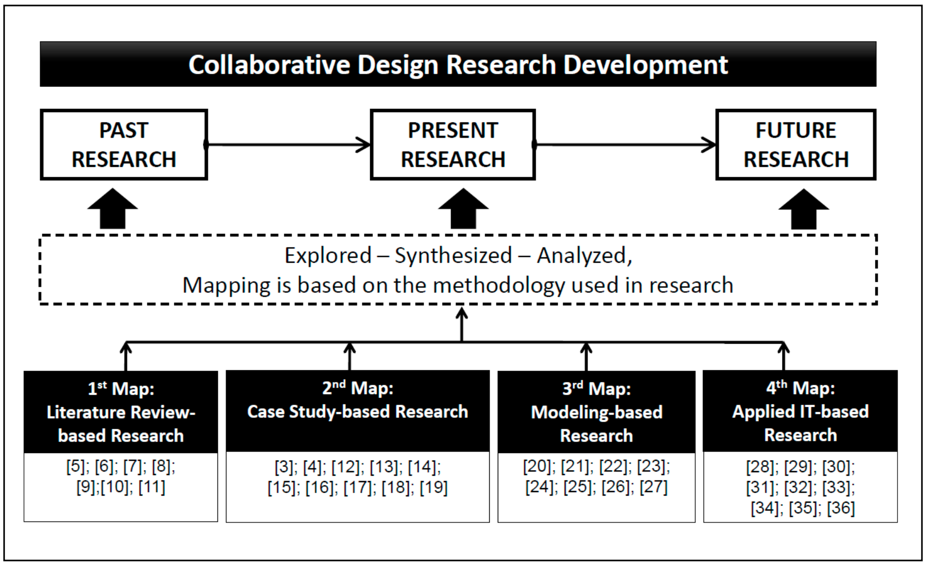

Figure 1. Conceptual figure of the literature review process [3–36].

2.1.1. First Map: Literature-study-based Research

There are two different approaches used for e-collaboration with the literature-study-based methodology. Some papers mainly discuss the tools and systems used to support the collaborative design process, and the rest mainly discuss the organization and participants. Emerging information technologies and communication infra-structures were involved in this research. Researchers concerned with technical factors are inventing tools and systems that can be used to facilitate the collaboration process. Dave and Koskela [5] explored computer functions to support collaborative works, and it was found that computer systems and tools are able to handle and facilitate problems of group size as well as the time and place availability of the participants involved. Computer technologies are used with the main purpose to create an environment of shared understanding [6]. The tools and systems make use of the Internet and web applications [7] and of (Computer Aided Design) CAD as collaboration media in conducting effective collaborative design [8]. Meanwhile, some researchers are concerned with social factors. Woo [9] explored the effects of approaches used for teamwork. Teamwork was also considered in [10], wherein task coordination and interdependencies in forming teamwork were explored. Social factors are also considered in [11], wherein the human factors that need to be considered in conducting successful collaborative design were explored.

Based on these reviews, there are two different paths in collaborative design research development. Some researchers think that technical factors are most important in collaborative design, and others think social factors are. Research on technical factors mostly considers the collaboration of design projects using tools and systems integrated with information technology and communication infrastructure development. Meanwhile, research on social factors mostly considers human factors, constructing and developing models and organizing participants towards improved interaction.

2.1.2. Second Map: Case-Study-Based Research

Case study research is exploratory and reveals facts from the field using real cases. The research explores the capabilities of tools or systems in supporting a collaborative design process. Other case studies are conducted to compile data and construct a model, whether it is conceptual or is a computer model. Data are mostly collected from observation and then recorded, and some are retrieved from interviews with participants. This research methodology is used to test the capability of invented tools and systems in facilitating the collaborative design process. The particular research is also used to explore data that will be compiled and analyzed to build a conceptual model that can lead to successful and effective collaborative design.

There are two categories of case-study-based collaborative design research, and they are divided in terms of purpose. The first includes case studies conducted to explore the capabilities of tools or systems facilitating the collaborative design process. These mostly consider the technical factors of collaborative design. The second category is concerned with exploring the behaviour of participants in collaborative design. These studies mostly focus on social factors that lead to a successful and effective collaborative design process.

One study in the first category [12] explored the advantages and disadvantages of supported equipment used for conducting collaborative design, especially in virtual environments. Results found that multi-media equipment needs to be considered to avoid the disadvantages caused by their use. New tools and systems influenced by the emergence of IT and communication infrastructure are in development. The limited time and place availability of participants was also explored. The use of a virtual environment in achieving a collaborative design process was supported. Case study research in [4] entailed that the collaborative design process can be conducted successfully using a shared workspace, where participants work together using one medium. Bosch-Sijtema et al. [13] revealed findings that strengthen the need for a shared workspace.

Regarding the use of virtual environments, Veeramani et al. [3] found that it is possible to conduct research based on virtual design studio facilities, but only design project collaboration can be facilitated. This is a collaborative process that is focused only on the object, and that does not facilitate the collaboration of participants involved. The virtual design process does not need to consider participants because the interaction can be stored textually, and this means that participants can easily track the design process, and misunderstandings caused by different perspectives can be avoided [14]. Misunderstandings can also be caused by different perceptions of knowledge or data. One problem in conducting a collaborative design virtually is managing data or knowledge that supports improved communication, especially in the negotiation and decision-making processes. Gu et al. [15] concluded that knowledge management is needed to facilitate decision making, especially in achieving design constraints. In line with this statement, Kvan [16] also concluded that it is important to manage data to support successful collaborative design processes through problem-solving and decision-making processes.

Some of the research reviewed was based on social factors. Wang et al. [17] found that designer behaviors in the design process affected the communication process. This needs to be considered when conducting an effective and successful collaborative design process, because it may take time for designers to adapt to other participants in collaborative work. Peng [18] found that, in conducting a collaborative design process using a Virtual Design Studio, social infrastructure through organization between participants needs to be considered. Thus, social factors also need to be considered in collaborative design—not only technical factors. This conclusion is supported by Veeramani et al. [3], who stated that a Virtual Design Studio is not made for people to collaborate but for the design object, so the problem will not be solved if only technical factors are considered. Social infrastructure through organization can be implemented by organizing participants into work teams or groups. Successful collaborative design can be achieved through integrated teamwork. It is important to organize participants into teams that can finish a task. Certain social factors can influence teamwork performance, i.e., personality, behaviour, motivation, satisfaction, etc. Lottaz et al. [19] found that social presence influenced the attitudes of participants in doing and finishing the task, and influenced successful and effective collaborative design processes.

It can be concluded that there is a destructive development path in the research. Research began with developing tools and systems to facilitate the collaborative design process. The tools and systems were made for collaboration in the design project or were mainly concerned with the object. Social factors were then considered. Social factors are needed to avoid or reduce problems related to participants. The collaborative design process not only focuses on the object but also concerns the source, i.e., the participants. An optimum solution can be achieved by utilizing knowledge from experts.

2.1.3. Third Map: Modelling-Based Research

There are three classifications of modelling-based research: physical modelling, conceptual modelling, and computer modelling. Physical modelling is used to create a mini version or copy of a real situation to investigate phenomena within the object of interest. Conceptual modelling is used to construct a concept to solve problems related to the interaction or connection between involved factors. Computer modelling is used to create programs that will be applied to a computer. Some steps need to be accomplished when building a model. The first step is to define the model by choosing its form: physical, conceptual, or computer. The model makes certain assumptions if too many variables are included. The next step is to create the model. The model needs to be tested in the next step, and the final step is the iterative process, where the model is simplified, and fitness with the problem and goal is found. Each journal is classified into one of two categories: defining systems and testing model cases. There are two ways to test models: comparing the model to other related models or matching the model with a real situation. Sometimes, an iteration process is needed in modelling-based research to simplify the model and fit it with the purpose of the research.

Most case study research requires a test case process to match it with actual conditions. Wang et al. [20] used a test case process to compare a model with other models with the same purpose to maximize the structured model. Meanwhile, Lahti et al. [21] combined both test case processes, tested the structured model by comparing it with other, similar models, and matched it with an actual condition. The modelling research involves conceptual and computer modelling. Each study has a constructive position in the collaborative design research area, supporting other research findings and contributing to the development of collaborative design research.

Some models were built or proposed to support the collaborative design process. Lu et al. [22] proposed the socio-technical framework, which can be used to analyze the collaborative design process, especially in relation to social relations among participants in which the cause of conflict can be seen. Another purpose of the model is to understand the interaction between conflict and the design process to increase productivity in the collaborative design process. This concept was then developed by Lu et al. [23] who explored an approach to facilitating collaborative design and built a socio-technical approach model that could be implemented and validated in the collaborative engineering process in the trucking industry. In addition to the importance of understanding the elements of social interaction among participants that are influential in the collaborative design process, the behaviour of participants in the decision-making process also plays an important role in the outcomes. Similarly, Lee and Gilleard [24] developed an ontology to describe participants' behaviour in a collaborative design meeting, especially in the decision-making process. Behaviour in decision-making activities was correlated by analyzing the agreement or acceptance of participants that affected the final outcome of a product. In efforts to achieve an optimal collaborative design result, Fountain et al. [25] built a computer model called feature-based collaborative design based on collaborative design processes in editing and producing drawings. The purpose was to facilitate a collaborative design process with participants located in different places and working at different times. The model made the drawing and editing process easier and made the problem-solving process faster.

The involvement of participants with different backgrounds facilitated the development of a managing and storing design process. Wang et al. [20] created S-DTPM (Socio-Technical Design Process Management) models that combined the concept of design rationale and design annotation in the graph design process to create a shared understanding between participants. The model was validated experimentally by applying the model to team mind software. The application combined graphic models from products and design documents. Lahti et al. [21] built a conceptual model that supported a data integration process for collaborative design by providing access to end users and by providing flexibility for participants participating in the design development process. A shared understanding and data integration [26] are needed to facilitate an improved communication process between participants. Du et al. [8] built a conceptual communication model that can be used to conduct effective collaborative design by building relationships and a team's cohesiveness.

There are three different backgrounds of approach used in modelling-based collaborative design. Some studies concern technical factors in conducting collaborative design, others concern social factors, and the rest concern a combination of these. Research on technical factors is mainly focused on facilitating the design process, which is achieved by creating a shared understanding environment and a shared workspace. Meanwhile, research on social factors mainly concerns the communication between participants, which can be influenced by participants' behaviour, attitude, motivation, etc. There has been some effort to combine technical and social factors. Based on our review, the development of modelling-based collaborative research is destructive, whereas there are some contraindications in identifying factors that need to be considered in conducting a collaborative design process.

2.1.4. The Fourth Map: Applied-IT-Based Research

The applied-IT-based research methodology is a method that is used to integrate systems and computer equipment with the development of information and communication technology so as to support and facilitate the collaborative design process. Computer systems that can be used in integrating information technology are divided into two categories: conventional programming and artificial intelligence (AI). Conventional programming is a simple system in making or writing computer programs using a traditional computer language procedure.

Several studies based on conventional programming support the collaborative design process by managing participants and data. Simeone et al. [28] developed a model to facilitate problems related to the geographical location of participants and to facilitate a mediation process between them by integrating a project planning process model (PPPM) with a web-enabled business to business (B2B) facility. The integration was used to build a virtual workspace to manage participants with different time and place availabilities. In addition to the need for managing the participants involved, a collaborative design process also requires the management of generated data. Kolarevic et al. [29] built an approach using a data mining technique to show an information pattern that can be used to manage information derived from the collaborative design process. In line with [29], Detienne [30] developed WordNet by building an ontology description language (FLO-DL) and introducing it to explain a global ontology library (GOL), which can be used to reduce semantic conflicts that often arise from inconsistent data. Another study [31] produced a semantic informative model that was similar.

AI can simply be defined as property or equipment in mind that has an ability to plan, solve, or resolve problems and provide reasons. AI can make correct decisions on inputs (that are given) and can select a variety of possible actions that can be used or applied to solve a problem. Some examples of AI applications are database search engines, expert systems, knowledge-based systems, Analytical Hierarchy Process (AHP), and Delphi. AI is used as a method in collaborative design research to facilitate the process of managing participants and data. Weinel et al. [32] developed a hypermedia system in the form of virtual discussion tables that can be used to expose data to participants. Gabriel and Maher [33] developed the intelligent system for interaction analysis in design (ISIAD), which is integrated with Boolean algebra and dynamic optimization operation, a kind of agent system that can be used to analyze participant dynamic interactions during the collaboration design process. The appearance of data in an idea representation activity can cause problems in the collaborative design process. This has made researchers pay attention to the process of managing inconsistent and ambiguous data. Leeuwen and Fridqvist [34] developed a system that can facilitate negotiation in the collaborative design process based on inconsistent data in communication activities. Haymaker et al. [35] used convolutional neural networks (CNNs) and BIM to develop image feature extraction to enhance the process of understanding design development.

2.2. Research Problem Statement

Figure 2 presents the results and conclusions of literature reviews. Based on the literature review of several journals related to the use of information technology applications in the collaborative design process, it can be concluded that several studies developed conventional programming and some developed AI. All research has similar objectives in supporting and strengthening the research on collaborative design by building systems and programs that facilitate a collaborative design process, especially by managing data during the process.

There have been problems in conducting a virtual design studio that facilitates a collaborative design process. Research was conducted to create a shared understanding and a shared workspace through data/knowledge management and the recorded design process. Some researchers have stated that facilitating collaboration functionally is of the highest priority [4–6,14], but others have stated that the need to consider the participants is [3,9,11] since functional facilities can only involve objects but not participants. Some researchers found that social presence related to participants influenced the result [8,10,18,19,24], and the optimum solution could not be achieved. Collaborative design research then considered social factors. Some researchers have tried combining technical and social factors [22,23]. Three elements of organizational systems can support collaborative design: human elements, technical elements, and informational elements. It has been found that, for a successful collaborative design process, two important aspects must be considered: social factors and technical factors.

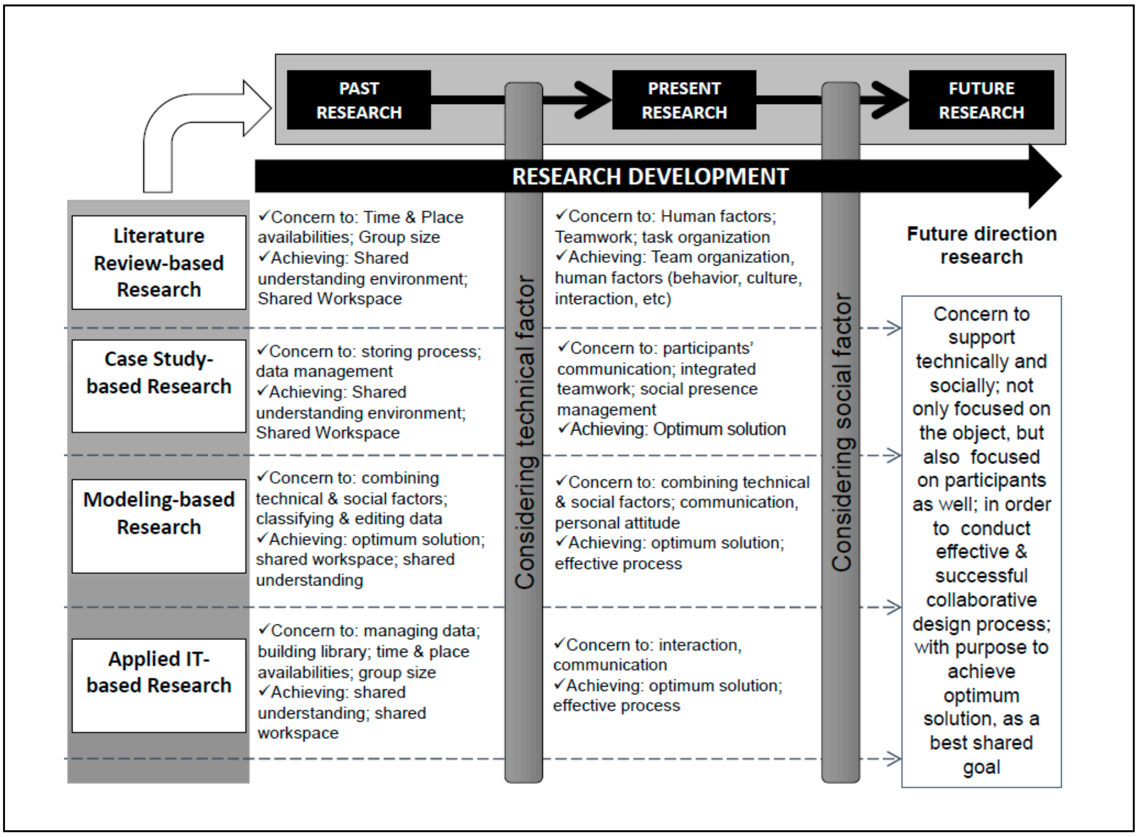

Figure 2. Literature review results.

Our review revealed that there are three main considerations to be made in e-collaboration and e-negotiation: technology, software (technical support), and social factors. Time and place availability issues between design participants call for a virtual solution. The development of ICT enables virtual collaboration using BIM. It was also found that the technology needs to be improved, particularly for those that are supporting communication. This is also related to the need to improve the software because design participants face technical problems. Major technical problems are related to difficulties in communicating design and may cause difficulties in making design decisions. Based on our review, all related factors have been investigated.

To confirm findings from the literature review, a preliminary study was conducted through surveys. There were 32 respondents involved in the survey. Respondents' details are presented in Figure 3, Figure 4, and Figure 5. Most respondents work in architectural design consulting, have a Master's degree, and have more than 15 years of experience in the design process. The respondents were interviewed about e-collaboration and e-negotiation practices in the design process and were asked about the importance of technology, software, and social factors in the virtual design process. Data were analysed using a scatter plot of mean and standard deviation, which is shown in Figure 6. A summary of the factors' level of importance is presented in Table 1.

Many respondents had different perspectives. Some respondents argued that social factors influence the e-collaboration process, while other respondents argued that these factors are not so influential because there are approaches that can be applied to minimize these factors' constraints. Similarly, regarding physical and technical factors, some respondents said these factors are essential and have an influence, but other respondents stated that they are not essential because their application sometimes does not contribute to e-collaboration success. For example, regarding the use of technology for e-collaboration and e-negotiation, if not all participants involved mastered the application in use, then the benefits will be difficult to achieve, as the technology will not provide any added value for the process, and even the process itself will suffer because it has to be repeated several times.

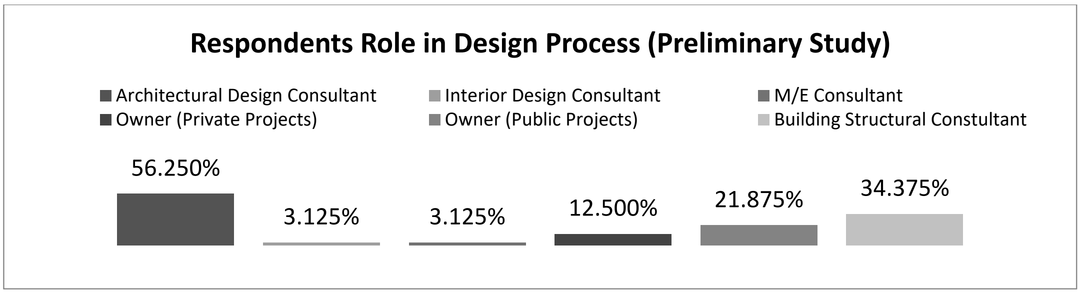

Figure 3. Respondents' role in the design process.

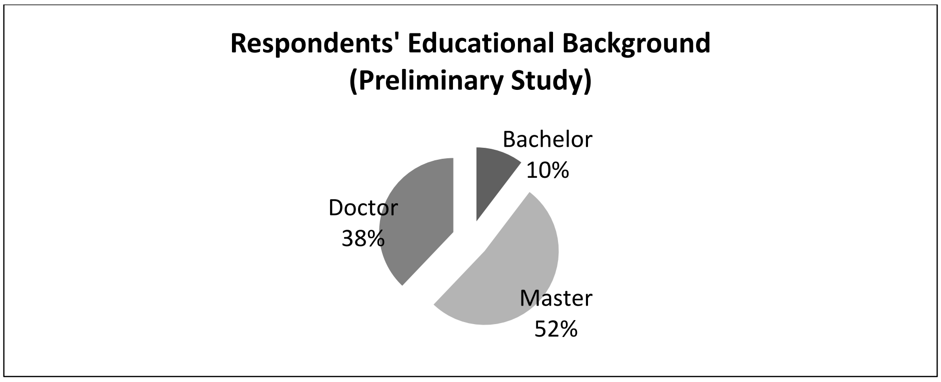

Figure 4. Respondents' educational background.

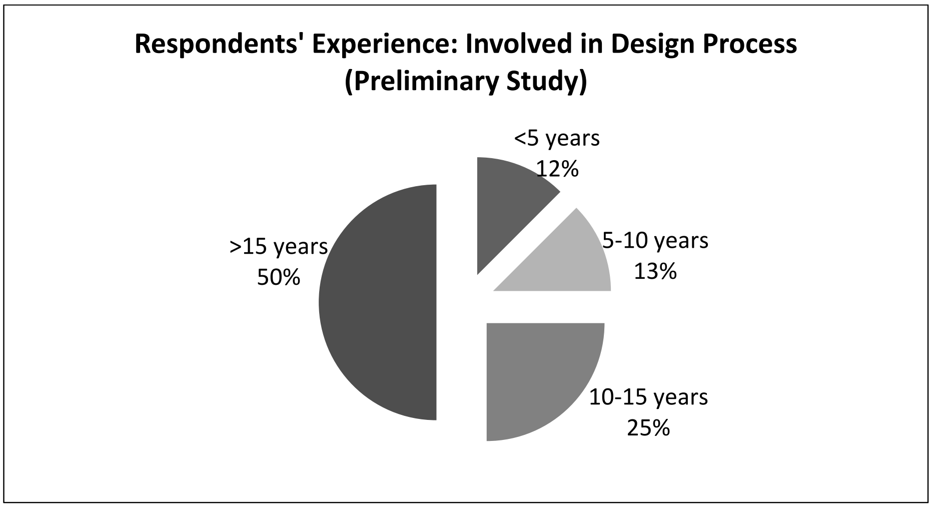

Figure 5. Respondents' experience.

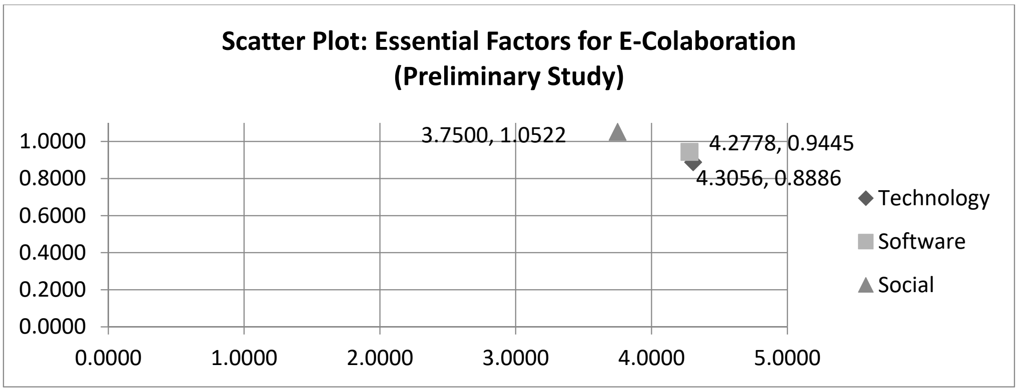

Figure 6. Scatter plot analysis for preliminary study.

Table 1. Analysis of the factors' level of importance (Preliminary study).

Factors	Analysis of Mean and Standard Deviation Scores		
	Mean	Standard Deviation	Rank
Technology	4.3056	0.8886	1st
Software	4.2778	0.9445	2nd
Social Factors	1.0522	3.7500	3rd

Preliminary study revealed that technology, followed by software and social factors, is the most important factor for supporting e-collaboration and e-negotiation in design. Designers must be aware of factors that support the design communication process, which involves sharing information and negotiation and decision making in selecting design alternatives. Our study found that communication and its facility for virtual collaboration in BIM and supporting e-negotiation is essential.

2.3. BIM Practices

The importance of communication and e-negotiation in BIM has also been highlighted in [37]. Main issues include not only the data but also how to socially and technically support communication and integration between specialists. The need for communication support in BIM practices is also corroborated by [13]. These findings suggest that BIM is not just a tool. It has been shown [38] that the professional development of BIM users also needs to be considered, and this indicates the importance of social factors for BIM. Organizational social factors need to be considered [39]. Based on findings from the literature review and from reviews on BIM practices, it can be concluded that both communication and e-negotiation factors are essential for BIM implementation.

3. Literature Review on E-Collaboration and E-Negotiation

Further reviews of past studies related to e-collaboration and e-negotiation in the design process were conducted to identify important factors that need to be considered.

3.1. Reviews on E-Collaboration in Design

Collaborative design is an approach that basically involves firms and participants from multiple fields simultaneously from the beginning to the end of the design process [5]. They are mainly involved to mutually decide the design development at every stage of the design process. Design via collaboration should be a result of negotiation and decision-making processes.

The development of ICT is involved in collaboration in the design process. ICT makes collaboration easier. Each firm or participant can collaborate globally. A virtual studio (BIM) has been developed in collaborative design studies because of ICT. This is the foundation of e-collaboration maturity in the design process. Some forms of virtual collaboration include the Phidias hypermedia system [12], featured-based collaborative design [21], and the shared design thinking process model [20]. Research is ongoing, and social approaches (leadership, human behaviour, personal communication styles, etc.) towards e-collaboration are likely to develop as well.

Collaboration between AEC consulting businesses is vital to achieve the optimal integrated design. Negotiation is an essential activity in facilitating collaboration and is needed to identify design alternatives that pay off optimally for each consultant and to find acceptable alternatives. With the development of ICT together with time and place availability issues, new e-collaboration and e-negotiation practices are blooming. Based on our review, illustrated in Figures 1 and 2, previous studies have developed tools, systems, or frameworks for both practices. It can also be highlighted that communication facilities that support e-negotiation are important. Technical factors and social factors matter.

3.2. Reviews on E-Negotiation in the Design Process

Negotiation is a critical issue in virtual collaboration using BIM. The implementation of e-collaboration makes the negotiation process more difficult. Firms and participants are forced to communicate their thoughts and negotiate design aspects virtually. Based on further reviews of previous studies, which are presented in Tables 2 and 3, two main factors for successful e-negotiation were found: facilities [21,29] and communication support [36].

Table 2. Factors of e-negotiation facilities.

Authors	Research Objectives	Justification	Support Factor
[40]	Developing systems that have capabilities in filtering and classifying data on design developments.	To organize data that are shared in e-collaboration that eases development of the design object.	Categorization of design
[34]	Developing a system that provides design criteria, which have capabilities in limiting the design development process.	To direct the process of design developments in gaining suitable alternatives that support the e-negotiation process.	Criteria for design progress
[29]	Developing a system that supports the process of design object modification by providing a system that has the ability to classify historical and hierarchical information about design developments.	To provide information on design developments that support easy access for participants in modifying the design.	Easy access in the design process and transforming the design objects
[21]	Developing a system that provides easy access for every participant to modify the design object. The system is also equipped with recording facilities that are able to record editing time and the version of modification.	To provide information on design developments.	Prompt information on design transformation

In sum, there are four factors of facilities and four factors of communication support. The facility factors are ease in accessing the design process and in transforming the design objects [21], prompt information about design transformations [29], design categorization, and criteria for the design progress. The communication support factors are a clear job description and organization structure, featured communication tools and systems, the existence of a design manager or coordinator, and the communication chain between parties [36].

4. Research Methodology

The research methodology is illustrated in Figure 7. Data were collected using questionnaires that measure and validate each criterion of e-negotiation (both facilities and communication support). There were 862 questionnaires distributed to designers who have e-negotiation and BIM experience, and 202 questionnaires were eligible to be analyzed. The 202 respondents were divided into two groups: leaders and non-leaders. Respondents who had experience in chairing a design process were categorized as leaders, and the rest were categorized as non-leaders. Descriptive analysis using a scatter plot of the mean and standard deviation was used to analyse data and to find the most important criteria for e-negotiation facilities and communication support. The analysis was also divided into two categories: leaders' perspectives and non-leaders' perspectives. The result was then synthesized using case studies of the e-negotiation process in three different consulting companies. Respondents' characteristics are presented in Figures 8–15, which consist of experiences involved in the design process and developing commercial properties, educational background, and repondents' role in the design process.

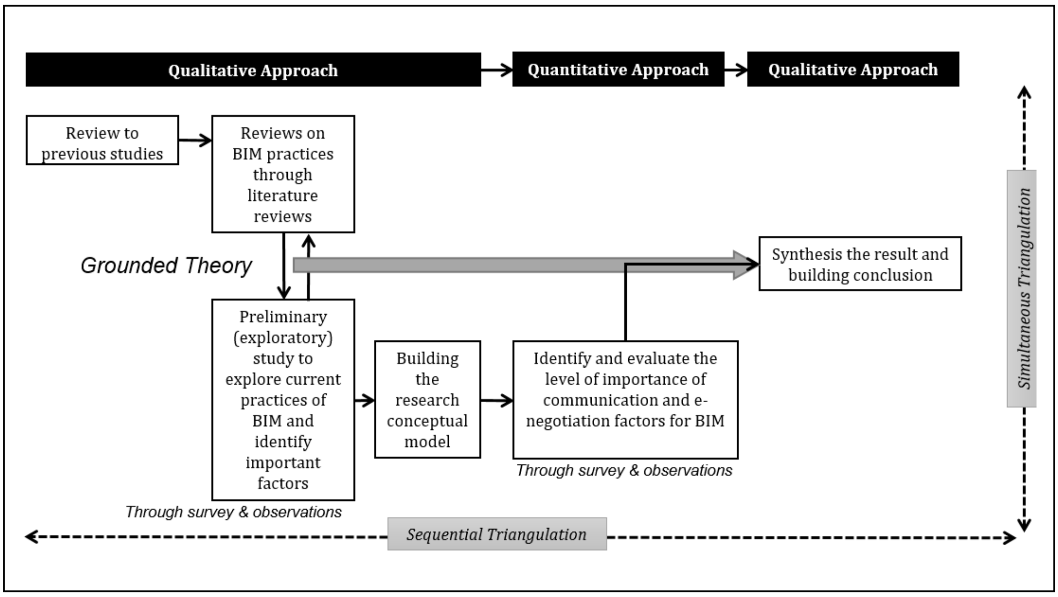

Figure 7. Research methodology.

5. Result and Discussion

The theoretical framework of this study was validated by 202 respondents, and the validated data were analyzed using a scatter plot of mean and standard deviation to rank the most important factors that need to be considered for e-negotiation success in the design process. This finding is essential for improving BIM tools and systems (Figures 8–15).

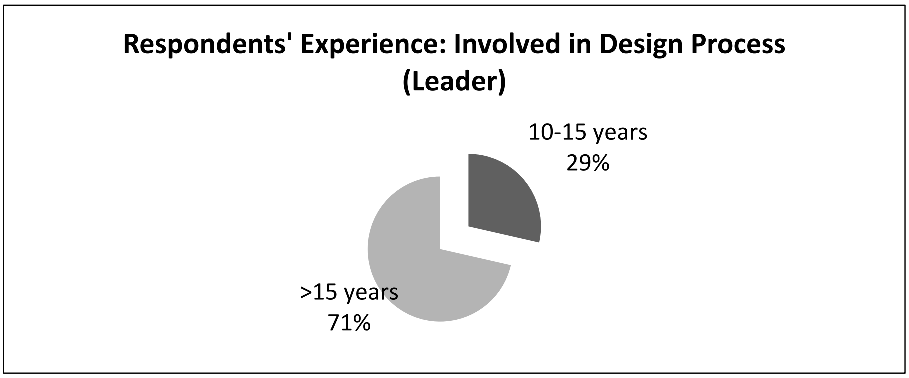

Figure 8. Respondents' experience involved in the design process (Leaders).

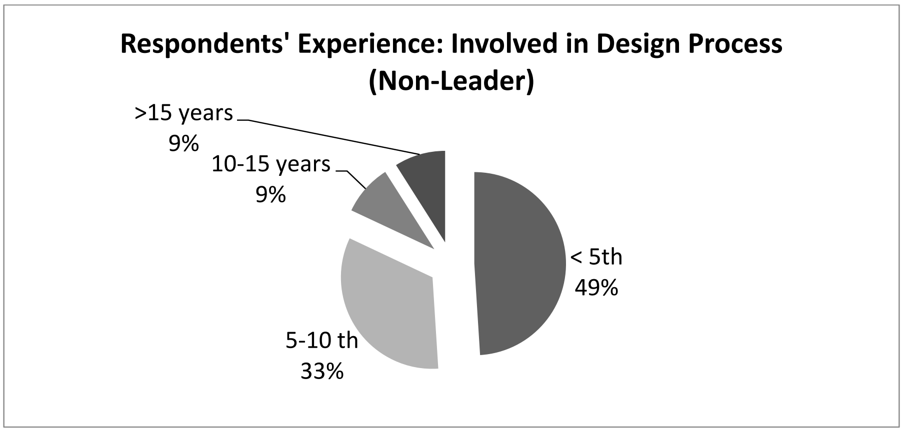

Figure 9. Respondents' experience involved in the design process (Non-leaders).

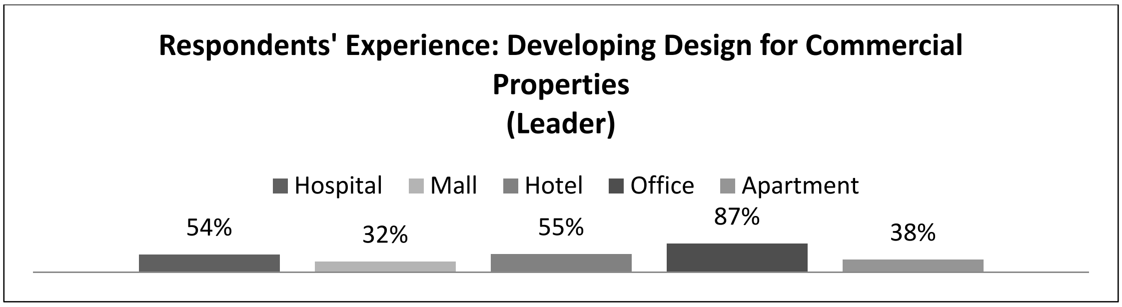

Figure 10. Respondents' experience in developing design for commercial properties (Leaders).

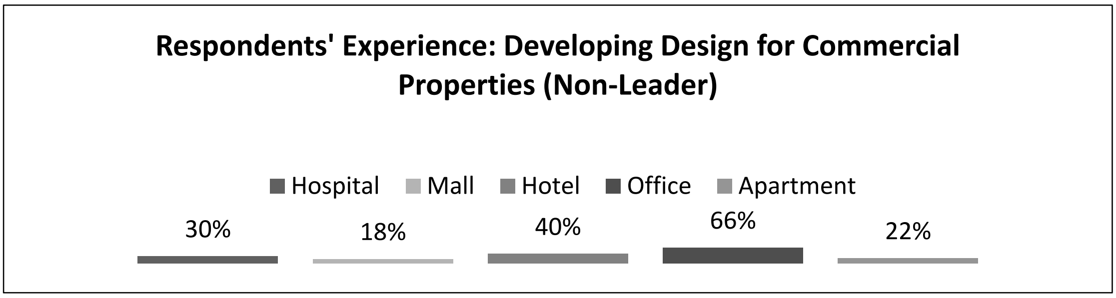

Figure 11. Respondents' experience in developing design for commercial properties (Non-leaders).

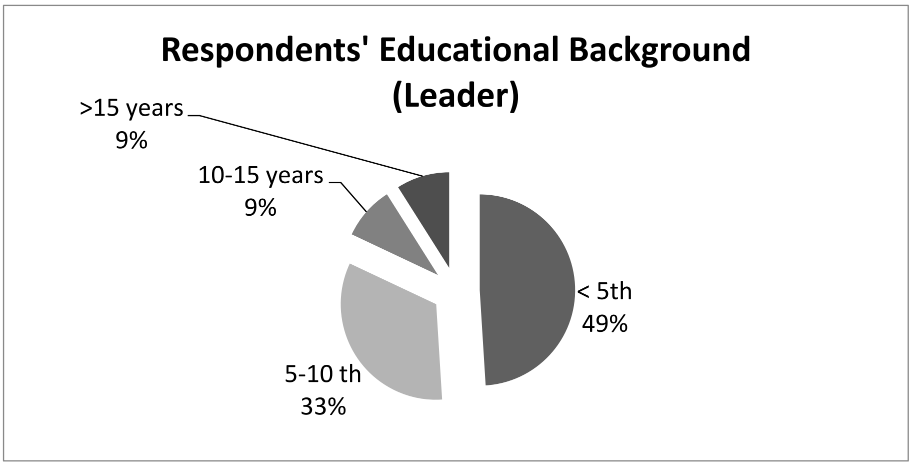

Figure 12. Respondents' educational background (Leaders).

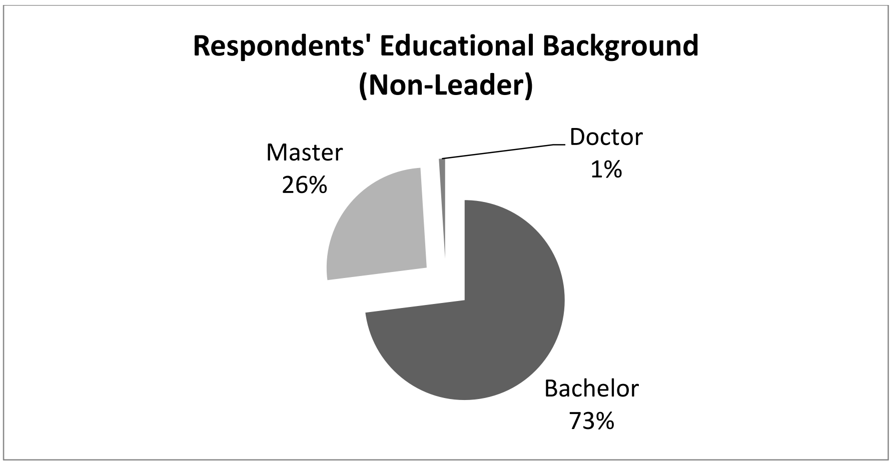

Figure 13. Respondents' educational background (Non-leaders).

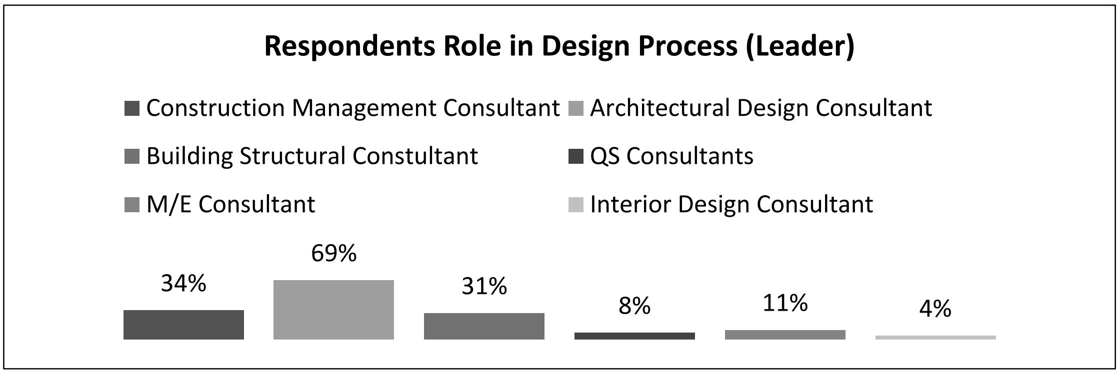

Figure 14. Respondents' role in the design process (Leaders).

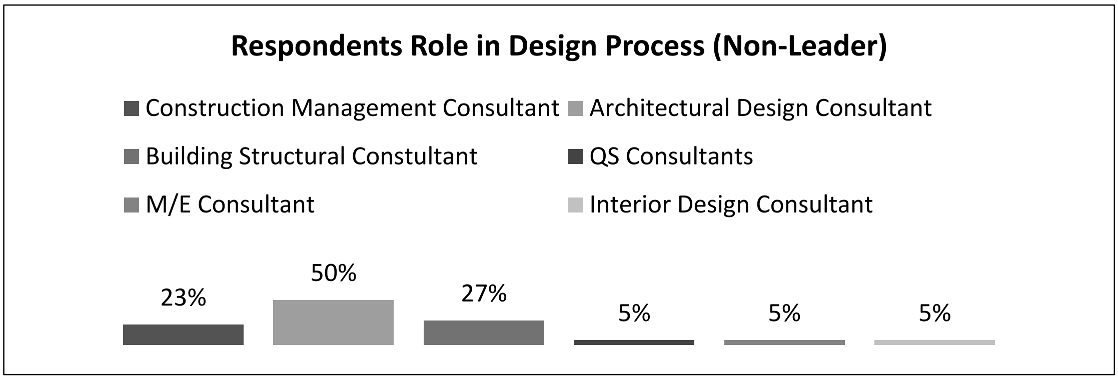

Figure 15. Respondents' role in the design process (Non-leaders).

5.1. E-Negotiation Facilities

Negotiation is one of critical issue in virtual collaboration using BIM. The implementation of e-collaboration made negotiation process more difficult. Firms and participants are forced to communicate their thought and negotiate the design aspects virtually. Based from further reviews to previous studies, which are presented in Tables 2 and 3, it was found two main factors for successful e-negotiation. The factors can be classified into facilities [21,29] and communication supports [36].

The analysis showed that every factor is essential. All mean scores were >3. It can be concluded that each respondent agreed that all factors are important. However, based on the standard deviation scores, each respondent had a different perception of the importance of each factor in e-negotiation facilities. Based on the scatter plot of the mean and standard deviation analysis for both categories (Leaders and Non-Leaders), as presented in Table 4 and Figure 16 (Leaders) as well as Table 5 and Figure 17 (Non-Leaders), it was found that prompt information of the design transformation was regarded as the most important support factor for e-negotiation facilities. Both groups revealed similar results. The factor considered the fourth most important was the criteria for design progress.

According to the case studies, this first factor is very important because it represents the capability to simultaneously help all parties to understand design progress and the editor's perspectives of design. As introduced in [29], the relevant situation has a positive impact in terms of eliminating missed perceptions between parties, and it also saves time in the e-negotiation process. In addition, there will be no extra time needed to obtain a similarity of perception between parties.

Differences were found in terms of what occupied the second and third places. Design leaders (directors/managers) agree that easy access in the design process and transforming the design is more important than the categorization of design. The leaders need to be able to directly transform and change the design. They also need to be able to conduct a what-if analysis of alternatives that reflect the owners' requirements. This was highlighted in [29].

Table 3. Factors of communication support for e-negotiation.

Authors	Research Objectives	Justification	Support Factor
[36]	Developing a conceptual framework of communication in the multi-participant design process regarding the activities of multi-task organization, sharing information, and the use of communication media.	To support effective communication and task organization carrying successful collaborative design	Job description and organization structure
[39]	Developing a theoretical framework of the design manager's support for successful e-collaboration and e-negotiation.	To support collaboration and decision making within the virtual design process.	The existence of a design manager or coordinator
[10]	Developing a framework of interdependencies and relationships between parties.	To support the communication between parties virtually by determining their relation and interdependencies.	Communication chain between parties
[41]	Discovering systems and tools that are most needed in supporting collaborative design; the communication facility is found to be the most supportive.	To support the activities of sharing information between participants.	Featured communication systems and tools

Table 4. Analysis of e-negotiation facilities (Leader perspectives).

Factors	Analysis of Mean and Standard Deviation Score		
	Mean	Standard Deviation	Rank
Prompt information of design transformation	4.3736	0.7249	1st
Easy access in the design process and transforming the design objects	4.4396	0.8460	2nd
Categorization of design	4.2527	0.8768	3rd
Criteria for design progress	3.8022	1.1759	4th

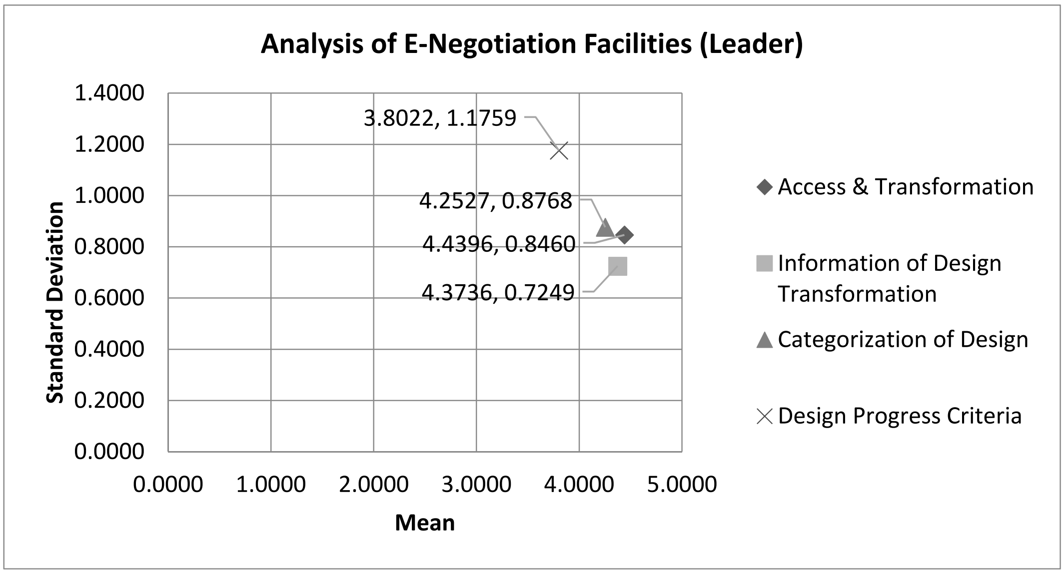

Figure 16. Scatter plot analysis of e-negotiation facilities (Leader perspectives).

Table 5. Analysis of e-negotiation facilities (Non-leader perspectives).

Factors	Analysis of Mean and Standard Deviation Score		
	Mean	Standard Deviation	Rank
Prompt information of design transformation	4.2523	0.8143	1st
Categorization of design	4.0631	0.8663	2nd
Easy access in the design process and transforming the design objects	4.1982	0.9421	3rd
Criteria for design progress	3.6667	1.0982	4th

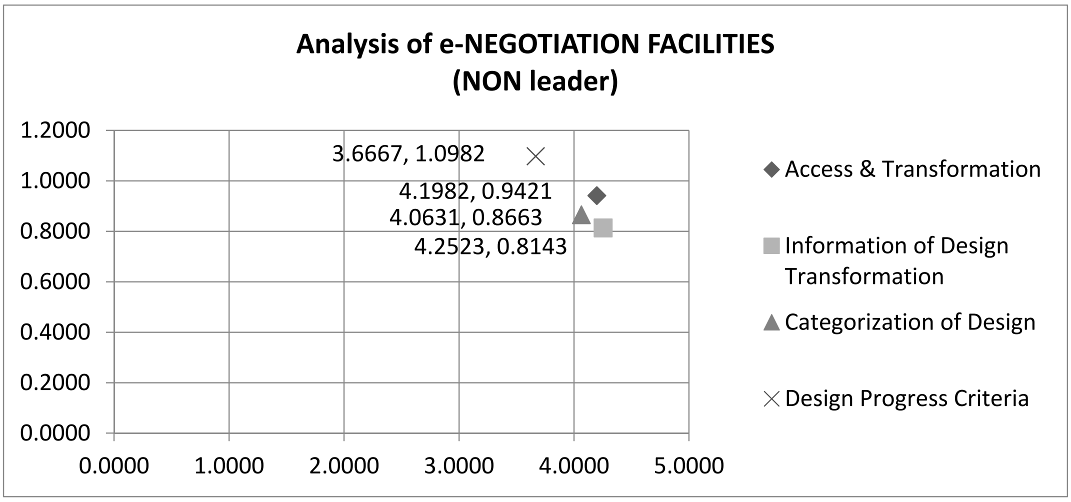

Figure 17. Scatter plot analysis of e-negotiation facilities (Non-leader perspectives).

For non-leaders, the categorization of the design is more important, since designers in this group usually work in detail (finishing the detail design). Classifying design aspects will support them in modifying or finishing a detailed design. This factor relates to the involvement of each consultant in the design process. Because of this factor, consultants will not spend much effort doing something that has no relation to their capability or expertise [17]. Based on the case studies, it was found that this factor has an enormous impact on the support of e-negotiation between consultants for complex designs. This is because design is now becoming more complex and involve diverse consultants. Multi-disciplinary parties are difficult to manage, especially in the e-negotiation process.

5.2. Communication Support for E-Negotiation

Four factors of communication support are also essential for e-negotiation. This was confirmed by our analysis, which is presented in Table 6 and Figure 18 (Leaders) as well as Table 7 and Figure 19 (Non-Leaders). Based on the scatter plot of the mean and standard deviation analysis, it can be concluded that all respondents agree on the positive influences of all factors on e-negotiation success. Comparable with the factors of facilities, each factor of communication support also has a different level of importance, which is shown from mean and standard deviation score.

Table 6. Analysis of communication support in e-negotiation (Leader perspectives).

Factors	Analysis of Mean and Standard Deviation Score		
	Mean	Standard Deviation	Rank
The existence of a design manager or coordinator	4.4396	0.7485	1st
Job description and organization structure	4.4615	0.7790	2nd
Featured communication systems and tools	4.2198	0.8407	3rd
Communication chain between parties	4.3516	0.9113	4th

The analysis reveals fascinating findings. Regarding the most important communication support factor in e-negotiation, both leaders and non-leaders have significantly different results. Leaders believe that the existence of a design manager or coordinator is the most important factor for supporting communication in e-negotiation, as revealed in [10,40]. Interestingly, this factor becomes the least important among non-leaders. The most important factor among non-leaders is the least important factor among leaders, which is the communication chain between parties.

The case studies show that this factor is less vital among non-leaders because of the existence of organization structure factors at the second level. The organization structure makes the communication flow obvious; every participant can use it as a guide in joining the e-negotiation process, even without a manager/coordinator. This result contrasts with [9], where the design manager/coordinator was found to be the most important factor for e-negotiation.

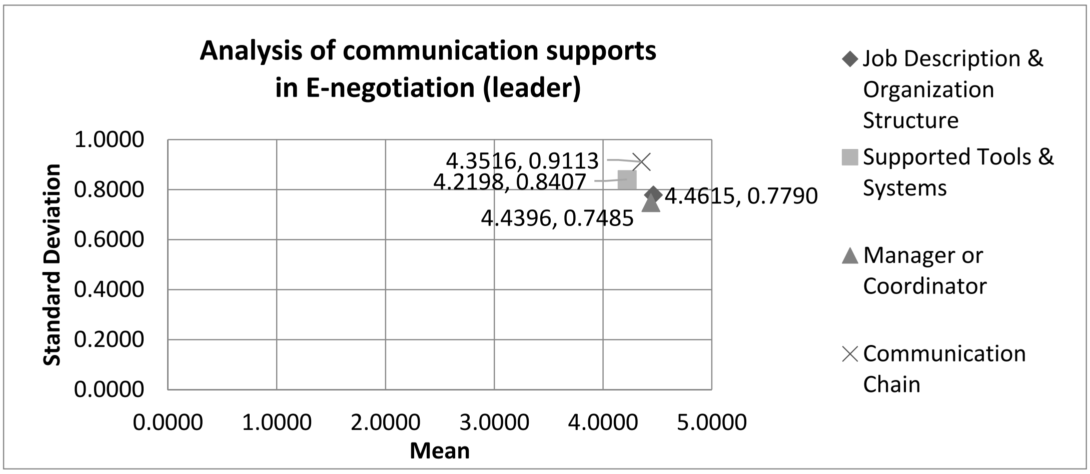

Figure 18. Scatter plot analysis of e-negotiation communication support (Leader perspectives).

Table 7. Analysis of communication support in e-negotiation (Non-leader perspectives).

Factors	Analysis of Mean and Standard Deviation Score		
	Mean	**Standard Deviation**	**Rank**
Communication chain between parties	4.2909	0.7083	1st
Job description and organization structure	4.0901	0.7810	2nd
Featured communication systems and tools	4.0000	0.7977	3rd
The existence of design manager or coordinator	4.1091	0.8918	4th

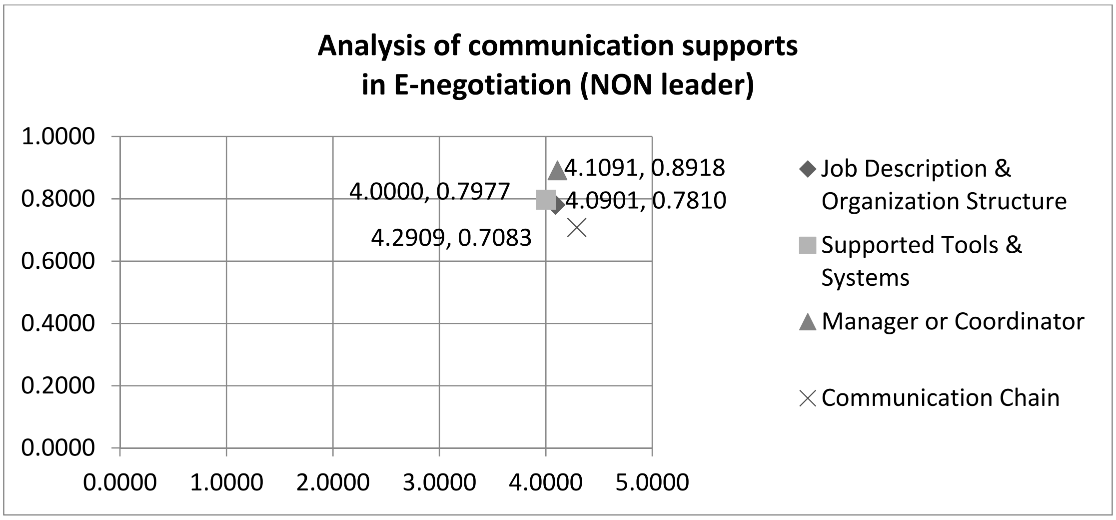

Figure 19. Scatter plot analysis of e-negotiation communication support (Non-leader perspectives).

Job description and organization structure occurred as the second most vital factor of communication support for both groups, as well described by [42]. The case study reported in [36] shows results that are similar to those of our case studies. This factor becomes vital because it determines the communication flow between parties. A centralized organisation structure has a communication flow different from that of the decentralized structure, where the negotiation process and results will also be different. The case studies here verify that this factor has a significant impact on the e-negotiation process. The e-negotiation result of the centralized communication structure is mostly narrow and dominated by top-level participants.

Analysis has shown that featured communication systems and tools are considered the third most important. Tools and systems are important in supporting the e-negotiation process, as stated in [14], which reports a case study with similar verification. Complications in conducting face-to-face meetings moved meetings into the virtual domain. Each participant was forced to join in virtual meetings as well as in virtual negotiations to make decisions on the design.

6. Conclusions

Both facilities and communication support are essential factors for e-negotiation success. The facilities consist of four main factors, and analysis has shown that prompt information of design transformation is the most vital factor in e-negotiation facilities. Based on leader and non-leader perspectives in developing CSCD and BIM, this factor is most important for e-negotiation success. Criteria for design progress are considered the least important factor for supporting facilities.

Communication support also consists of four factors, and the analysis revealed interesting findings. Leaders considered the existence of a design manager/coordinator to be the most important factor, but non-leaders considered this the least important factor. Non-leaders considered the communication chain between parties to be the most important factor, and leaders considered this the least important factor. This is a result of decision-making practices that are usually centralized.

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