Research in Management of Technology and Business Vol. 2 No. 2 (2021) 395-414

RMTB

Homepage: http://publisher.uthm.edu.my/periodicals/index.php/rmtb
e-ISSN : 2773-5044

Building Information Modeling (BIM) Implementation Towards Improving Collaborative Communication in Construction Projects

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DOI: https://doi.org/10.30880/rmtb.2021.02.02.030
Received 30 September 2021; Accepted 01 November 2021; Available online 01 December 2021

Abstract: Collaborative communication (CC) in construction projects have become a key issue to be addressed as CC is considered as main factor of project success. Building Information Modeling (BIM) has been recognized as a method to improve CC. However, BIM implementation is challenged by the current practices of traditional CC in construction industry. Objectives of this research are therefore to identify CC issues in the current practices among project participants, to determine the benefits of BIM in improving CC and to assess the potential ways to enhance CC with challenges in BIM implementation for construction projects. Data collection method used is qualitative method, whereas interview was conducted with project participants in Kota Kinabalu, Sabah that are familiar with BIM implementation for CC in construction project. This finding found that all respondents agreed on CC issues that consist of practices of poor CC, non-standardised information sharing, low level of CC, and lack of advance technology support. Respondents agreed that with BIM implementation, it improved CC with better project visualisation, as a single environment platform, integrated CC, and increased productivity of construction projects. Potential ways for BIM implementation are compulsory of BIM implementation in contract document, provide training such as workshops, Webinar, subsidies from Government, promote BIM extensively through BIM implementation in Government project, and investing on technologies tools for online interaction. In conclusion, this research encourages the stakeholders to implement BIM for CC

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among project participants. Further research should be focus on how to utilize BIM in project management during COVID19 crisis.

Keywords: Building Information Modeling (BIM), Collaborative Communication, construction projects

1. Introduction and Research Background

Many researchers explored the contributions of the construction industry towards the economic development of nations. According to Abubakar *et al*. (2018), the construction industry plays a major role in the growth and development of all economies by providing infrastructure for other productive sectors, provides shelter and generates employment to people of different knowledge and skills. The construction industry, however, is a complex enterprise consisting of stakeholders that work on the construction project in different phases. The project participants' engagement requires that knowledge to be interpreted and transmitted within themselves to achieve the project goals for a successful collaboration and communication (Olanrewaju *et al*., 2017).

Mavuso *et al.* (2016) further indicated that effective communication during the project lifecycle is a stimulus to project success. Unfortunately, for a long period of time, there have been criticisms in the construction industry, where most issues are attribute to poor collaboration and ineffective communication among the project participants (Soliman, 2017, Goh *et al*., 2014, Mirawati *et al*., 2015). As a result, the stakeholders have been encouraged to identify possible instruments to address the collaborative communication problem in construction projects and thereby increase project efficiency. Consequently, past research has shown that the Building Information Modeling (BIM) has become a medium for increasing collaborative communication among the project participants. BIM is considered relevant as collaborative communication tools because of its ability to share ideas and visualizes the project better than the traditional method and eventually can improve the collaborative communication among the project participants (Melzner *et al*., 2015, Svalesteun *et al*., 2017, Schaft, 2018).

In Malaysia, the Director of the Public Works Department (PWD) presented the proposal to incorporate BIM in 2007 (Haron *et al*., 2017). The National Cancer Institute of Malaysia in Putrajaya, accompanied by other projects under the BIM pilot Programme, such as the Type 5 Pahang Healthcare Centre, and Suruhanjaya Pencegahan Rasuah Shah Alam Administation Complex, is the first project in Malaysia to introduce the BIM application. In these pilot projects, BIM was used during the design phase such as location simulation, visualization, design assessment, conflict evaluation, 4-dimensional (4D) planning and simulation and modeling documentation (Latifi *et al*., 2013).

Although most of the construction organisation in Malaysia already have an insight about the use of BIM in construction project but due to the absence of proper guidance, government support, and well-trained personnel, this causes a slow rate of the adoption of BIM (Rogers *et al*., 2015). In addition, it is reported that the current level of BIM adoption in Malaysia (49%) is lower compared to United Kingdom (69%) (CIDB,2019). This shows that Malaysia has a major setback for adopting BIM in construction project when compared to US which crossed the gap within 5 years of the introduction of BIM into their industry (Porwal & Hewage, 2016). Růžku (2016) has quoted Berita Harian where the chief executive officer of CIDB, Datuk Ahmad Asri Abdul Hamid in a press statement saying that it will be mandatory for developers to use BIM by the year 2020 for their construction works. The Public Works Department (JKR) through their Strategic Plan 2021-2025 also has targeted the BIM adoption to reach 80% by the year 2025. The BIM is aimed to be utilized not just during the planning and design phase, but also during the implementation phase where the construction is ongoing (Aziz, 2020). This shows the Government effort to encourage the industry player to implement BIM in the construction projects.

As a result, these findings create a direction to research on the factors that affect the collaborative communication among the project participants in construction projects. Besides that, this also creates the need to study the benefits of the BIM technology method implemented in Malaysia construction industry in dealing with the collaborative communication problems among the project participants in construction projects.

Collaborative communication (CC) is defined as the effective communication system and collaboration in which individuals working together towards a shared purpose and mission. CC is considered as one of the key factors to deliver success in construction project (Olanrewaju *et al*., 2017). Construction projects that practiced the traditional method of construction project delivery often posed challenges in collaborative communication among project participants (Nawi *et al.*, 2014). Soliman (2017), quoted the factors that influence the traditional CC approach can be characterised by a lack of sense of identity, promoting a conferential culture and lack of feedback loops or coordination among the project participants. Furthermore, Mirawati *et al.* (2015) reported that inadequate coordination and the loss of confidentiality amongst project participants resulted from weak CC. Rahman *et al.* (2012) further indicated that the cost and time overruns in the Malaysia construction projects were due to ineffective ICTs used for communication. In addition, cost and time overrun in the construction projects were due to discrepancies among stakeholders (Spang & Riemann, 2014). This indicates that the poor CC among the project participants established an adversarial relationship and disputes among the project participants.

Generally, there are two method of CC that is used in the current practice of construction industry: Traditional method and BIM method. Traditional method is a method where the project participant used CAD-based technical documentation to provide information regarding the construction project. This method is considered ineffective, particularly during the documentation preparation. Its lack of correlation between the drawings requires manual interference for each drawing when design modification is required, and this increases the possibility of imprecision (Pszczolka, 2019). The communication tools used in traditional method are consists of e-mails, faxes, meeting minutes, phone calls etc. and often non-standards messages are exchange between them (Geren, 2012). This in return, resulting to information being overlapped. Due to lack of proper information flow and drawings documentation, it increases the risk of inaccuracy and miscommunication will occur (Pszczolka, 2019). In contrast, BIM-based method is considered beneficial to work with as the technology enables users to coordinate, communicate, analyse, manage project and hence to design more precisely, minimise mistakes, decrease waste, increase safety, and enhance efficiency during construction (Pszczolka, 2019). For integrated collaboration and communication between the diverse stakeholders from the same and other project phases, the BIM technologies can be utilized. For example, BIM offers an excellent alternative to 3-dimensional (3D) computer aided design modelling. This decreases the processing and duplication of drawings for different requirements of the project participants as the model contains more information than a 2D drawing set, which allows each stakeholder to annotate and connect their ideas to the project (Bwail, 2018). With collaboration and relevant understanding of the project, this contributes to increase in quality of documentation and reduction of risk associated with the exceed of construction cost and time (Pszczolka, 2019). Although BIM is considered as a tool for collaboration and communication, but it is seen that in Malaysia the level adoption of BIM is still lower compared to other developing countries (Amiruddin, 2019, CIDB, 2019). Therefore, potential strategies needed to be identified to overcome the challenges in improving CC with BIM implementation in the construction industry specifically among the project participants in construction projects.

The objective of this research is mainly to confirm that the implementation of BIM in the construction project, through a literature review and interview, can have positive impacts in improving collaborative communication among the project participants. The objectives are to identify the problems of current practices in construction projects among the project participants regarding collaborative communication, to determine the benefits of practicing collaborative communication using Building

Information Modeling (BIM) for construction projects and to assess the potential ways to enhance collaborative communication with challenges in Building Information Modeling (BIM) implementation for construction projects. The scope of the research is focused on both government and non-government projects in the Malaysian construction industry and is limited to the BIM technology approach. The target respondents are among the project participants of contractor G7 that are involved in the construction projects in Kota Kinabalu, Sabah.

2. Literature Review

This section explains further on the discussion of terms, definitions, and theories about the collaborative communication (CC) in construction industry, problems of CC in the current practices of construction projects, benefits of BIM technology to improve collaborative communication (CC), and potential ways to overcome CC with BIM implementation.

2.1 Collaborative communication (CC) in construction industry

Collaboration is the process of interaction in which the teams are working together towards one project goals. Collaboration is important because it will benefit the construction project as more people can contribute more ideas, boost productivity, and increase the success rate to achieve the goals. According to the Slack survey, the preference of good collaboration includes trusting the team member to perform a good work, having clear responsibilities and able to communicate with the team member effectively (Phlips, 2019). In another survey done by Rahman *et al.,* (2014), six significant factors have been identified that initiated the readiness to cooperate among contractors. These factors include (1) collaboration promotes teamwork; (2) similar racial collaboration establishes teamwork among project participants; (3) motivate knowledge sharing; (4) increases efficiency and prompt execution of project; (5) improves quality of service; and (6) improved communication between project participants.

Contrarily, the transmission of information is a process involves ideas, knowledge, facts, skills, and technology. Communication is not just a way to transmit information, it is also a type of interaction that escalate the knowledge sharing to guarantee the project's success (Park & Lee, 2014). Moreover, communication encompasses various aspects related to production, compilation, sending, storing, distribution and managing project records. Communication also needs an accurate report on the progress of project, project performance, and change and earned value. The correlation of CC can be seen in its shared value which is the exchange of information. Collaboration merely adds the objective of pushing the collaborative product forward, but collaboration cannot happen without communication. Collaborative communication depends on the prompt communication in which any delay in transferring crucial information can lead to misinterpretation and problems escalation (Geren, 2012). Therefore, collaborative communication (CC) in construction means the involvement of many stakeholders that able to cooperate, compromise and interact to fulfil the project's goals.

2.2 Problems of Collaborative Communication (CC) in the current practices of construction project

The construction practitioners have actively investigated collaborative communication (CC) in the construction industry. The concern of studying CC issue is due to its impact in the construction industry, where it is one of the primary reasons of project failure (Abdul Rahman *et al*., 2013). The are many factors that affect the CC in the construction project which then lead to construction problems such as delay, time and cost overruns, inefficient productivity, poor quality of the project, disputes and increase adversarial relationship. The factors are shown in the Table 1 below:

Table 1: List of construction issue that are related to CC (Soliman, 2017)

Factors that affecting the CC in construction project	Effect towards construction project
• Fragmentation in the construction projects (Nitithamyong & Skibniewski, 2004)	Problems in communication and information processing. -Increase in adversarial relationship between parties to a project
• Low communication efficiency during the project changing order, slow decision-making process, and inadequate supervisory authority (Koushki *et al*., 2005 & Tabtabi, 2002)	Leads to delay in project
• Disagreement among stakeholders because of poor CC (Spang & Riemann, 2014)	Created an adversarial relationship and disputes.
• Lack of communication mechanisms, weak organizational structure of construction team, lack of uniform standards for construction information, and lack of support for advanced communication technologies. (Tai *et al*., 2009) • Lack of sense of identity, promotes conferential culture and lack of feedback loops or coordination (Abadi, 2005; Dainty *et al.*,2001)	- Caused communication problems between owner and project manager. - Obstruct communication and insufficient knowledge transfer. - Affected the quality of communication & collaboration
• Ineffective Information and Communication technology that are used for communication (Rahman *et al.*, 2012)	Cost and time overruns

2.3 Benefits of BIM implementation to improve CC throughout the construction lifecycle.

Several studies have made conclusions regarding the benefits of BIM adoption in enhancing the collaborative communication among project participants could significantly improve productivity and leads to project success. According to the survey done by Goh *et al*. (2014), BIM technology have helped the project participants to overcome the problems in construction project and improve collaborative communication whereas all the data in the model are displayed clearly and precisely, better project visualisation, combines all concept from different stakeholders, capable of showing project construction similar with the drawings, facilitate management process in construction industry and improves the communication among project participants that are centralised within the BIM system. BIM also can be described as the tools for a faster and reliable and decision-making, better communication model, better quality of project produces, enhanced profit, smarter architectural simulation, and consistent and non-redundant provision of data, including enhanced data delivery process (Wong *et al*. 2010).

Moreover, as the use of BIM advanced, collaboration between the project participant increase, which will lead to enhanced profitability, decreases costs, better time management and enhance customer-client relationships (Azhar *et al*., 2011). BIM has become a tool to enable higher productivity by improving the management of information in construction projects where it enables more collaboration within the fragmented AEC industry (Kiviniemi, 2013). Moreover, through BIM, construction projects problems such as ineffective and inefficient construction process can be solved (Latifi *et al*., 2013). Furthermore, Samimpay & Saghatforoush (2020) in their study reported that during the BIM improves the communication among all stakeholders, better clarification of project concept

that led to end product that satisfy the Client, better information management and improved documentation, better understanding of construction components, increase coordination and integration among design, construction and logistics team, improve project quality, improve decision making power of contractors, reducing project construction time and cost, reduce conflicts, better decision making, and support of performance of project lifecycle. The time and cost of construction can be efficiently control with the help of BIM in improving the schedule and drawing coordination. Moreover, through BIM, construction projects problems such as ineffective and inefficient construction process can be solved (Latifi *et al*., 2013).

2.4 Potential Ways to Overcome CC with BIM Implementation

Over the years, several approaches have been created to incorporate BIM in the construction project specifically to overcome the issues of CC among the project participants. By implementing BIM technology not only for the design team but also for the construction team on site, allowing access to the model wherever they are, issues can be identified and addressed early on. According to Van Berlo & Natrop (2015), they claimed that paper drawings appear to control information in the workplace. In addition, they suggested that with BIMs on site, it can achieve a great opportunity during the construction phase and the construction workers benefit from simulation as they interact using BIM on-site.

In another study by Vestermo *et al*. (2016), the results findings showed that there are three methods of BIM implementation that the current industry players have practiced in the construction projects to improve the level of collaboration and communication among the project participants. These three methods are: (1) On-site computer terminals (also known as BIM stations); (2) mobile devices such as tablets and (3) advanced environments (e.g., BIM caves). The BIM stations is an on-site information too in which a computer is connected to a TV-screen to help visualising the model and therefore facilitate the workers to determine the solutions for practical problems on-site. The BIM-station allows the project participants to access to the most recent BIM-model and drawings. Moreover, the BIM-stations also enables the collaboration internally and between different disciplines especially during the decision-making and problem-solving process. Vestermo *et al*. (2016) further indicated that the BIM-station benefits in improving the availability of information on-site, adequate amount information to achieve the project goals can be obtained by the project participants, promote a better collaboration between different parties, and higher productivity of the construction projects. Moreover, Harstad *et al*. (2015) in their study also shows how tablet were utilised on the construction projects. According to Harstad *et al.* (2015), the tablet application has benefited the project participants on-site with an easy access to information, reducing errors due to the old drawings, requires less printing and distribution of paper documentation, portable, reduce time on monitoring process, faster decision-making process, improves documentation and reports, reduce unnecessary movements, and also creates a new line of communication.

In addition, findings by Kang & Kuncham (2014), demonstrated that the BIM-Cave timeline makes the 4D construction sequence visualisation more effective than viewing the 4D construction sequence on a single screen. They specified that the BIM-Cave offered a better spatial perception of building spaces and facilitates many project participants who can work together to resolve issues compare to a single screen desktop screen. Furthermore, Svaslestuen (2017) in his findings reported that previous researcher has done research towards how BIM implementation in the construction project can help to solve various issues involving collaboration and communication.

In Malaysia, the infrastructure project of Klang Valley Mass Rapid Transit (KVMRT) SSP Line is the first infrastructure project that has succeed of implementing BIM Level 2 with the combination of cloud-based collaboration on Common Data Environment (CDE) in two project packages: the underground design and build package, and elevated and system works packages (Construction Plus, 2019). The combination of the BIM technology and cloud-based collaboration has benefitted the project

to a 35% increase in the design, construction, and operation of the infrastructure through seamless information sharing and collaboration between the project participants (Gnaneswaran, 2017).

3. Research Methodology

Research methodology is a compilation of systematic method used in research. This chapter outline in detail, research process, data collection, data analysis, population and sampling research, research instrument and finally conclusion.

3.1 Research Process

Figure 1 below shows the research process of this study.

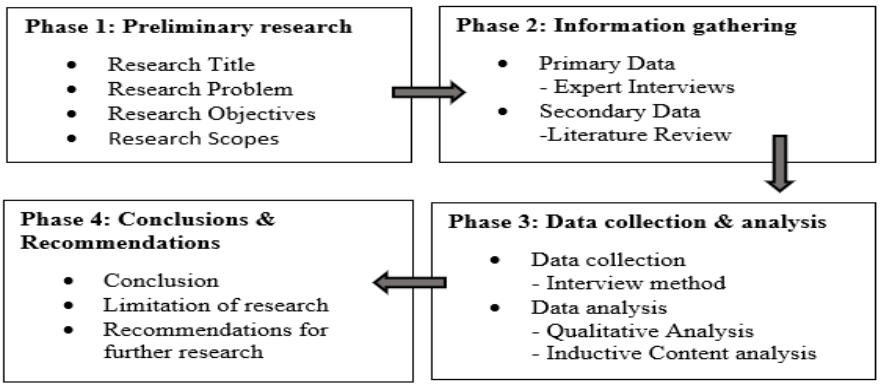

Figure 1: Research Process

3.2 Data Collection

Data collection is the method of gathering and assessing information on a systematic target for sustainable variables. After that, it requires others to answer the related questions and assess the findings. This research is a qualitative research that include both primary data (interview method) and secondary data (literature review).

(a) Primary Data

According to Yusof (2003), primary data are data extracted from natural sources gathered to address research questions. These data are obtained by researchers through experimental processes or field studies, such as questionnaires, analyses, interviews, etc. The researcher used interview method where the respondents were interviewed in real-time interaction. For this research, semi-structured interview was used. Semi-structure interview are those in-depth interviews where the respondents have to answer pre-set open-ended questions. Semi-structured interviews comprise of several critical questions that assist in outlining the themes to be studied, but also enable researchers or respondents to differ to explore a more detailed thought or answer. In responses to the new norms because of COVID-19 pandemic, face-to-face interview is unable to be carried out. Therefore, telephone interview and online interview which happen in real-time is chosen so that respondents from different locations can be reached easily.

(b) Secondary Data

According to Marican (2015), secondary data obtained by other researchers may be described as data. For instance, past or previous data that were collected for research purposes. The data is still acceptable and relevant for answering research questions or expanding to new information or

formulations for current research. Literature review is one of the examples of source for secondary data. Literature review is an excellent method of synthesising the research findings, which is a key component of the development of conceptual models, in order to provide evidence on a meta-level (Snyder, 2019). Several key points have been identified from the literature review on the problems of the current practices of collaborative communication among project participants. These problems consist of practice of poor collaborative communication, non-standardised information sharing, low level of collaborative communication during decision-making process, lack of advance technology supports (Soliman, 2017). Furthermore, benefits of BIM to be implemented in the construction project as a way to improve the collaborative communication between project participant were also identified during the process of literature review. The benefits consist of better project visualisation, integrated collaborative communication, BIM as single environment platform, and BIM-based collaborative communication effect towards the productivity of the construction projects (Goh *et al,* 2014, Samimpay & Saghatforoush, 2020).

3.3 Data Analysis

In this research, two types of data analytics are used: qualitative analysis and inductive analysis of content. Analysis of qualitative data like text data from interview transcripts is a qualitative analysis. In quality analysis the focus is not on the prediction, but on the identification and comprehension of a statement. This form of analysis is addressed by qualitative methods like interviews and surveys. Next, inductive content analysis is a research tool used to determine the presence of certain words, themes, or concepts within some given qualitative data such as text. Using inductive content analysis, researchers can quantify and analyse the presence, interpretations and relationships of such certain words, themes, or concepts. In this research, each interview was audio recorded and transcribed. Thereafter, the transcribed data were read repeatedly to obtain in-depth understanding before categorizing the data. Next, the data categories were broken down according to the objectives in this study and then is further broken down into smaller sections that focus on the key points for each question posed to the respondents. This facilitates the analytic process and compares data from different respondents' responses.

3.4 Research Population

For the research purpose, target population is chosen to increase the probability of successful data collection. Target population involves the entire group of people or objects which is suitable to generalize the study findings and meet set of criteria of interest that might answer the research questions. In this research, the target population is focused on contractor of Grade 7 in Kota Kinabalu, Sabah that are registered under Construction Industry Development Board (CIDB). This permits them to undertake civil engineering construction and building construction projects for an unlimited amount. Based on the findings on Centralized Information Management System (CIMS), a total of 457 numbers of Grade 7 registered contractor company is identified (CIDB, 2021).

3.5 Research Sample

A sample is the specific group that researcher will collect data from. The size of the sample is always less than the total size of the population (Bhandari, 2020). Sampling is the process of selecting a group of people, events, behaviors, or other elements with the purpose of researching. Because of the larger and more dispersed populations and with the limitation of time and cost, it is considered difficult or impossible to collect data from every individual in the target population. Therefore, sampling method is used to make more precise inferences about the population. 5 samples are chosen which is consist of engineers and quantity surveyors. The respondents were chosen because of the qualification and suitableness that fits the objectives of this research. All the respondents have knowledge and/or have experiences in using the Building Information Modeling (BIM) in collaborative communication (CC) among other project participants in construction project.

3.6 Research Instrument Development

Research instrument refers to the tools researchers uses to gather or get data, to measure data, and to analyse data related to the research issue. Research instrument must be able to facilitate the researcher in answering the research purpose, objectives, and questions. The research instrument development for this research were divided into two stages: pilot study stage and actual interview stage as shown in Figure 2.

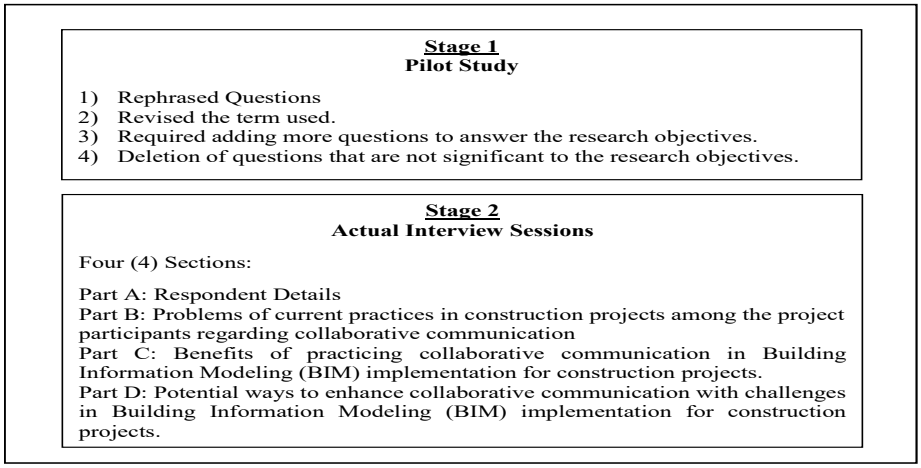

Figure 2: Research instrument development process

(a) Pilot Study

A pilot study involves a small study in preparation for a bigger research to verify research procedures, data gathering tools, sample recruitment tactics and other research methods. An essential phase of research is a pilot study utilized to detect prospective issue areas and deficiencies in research instruments and methods during complete research before deployment (Lancaster et al., 2004, Kraemer et al., 2006). Figure 3 showed the pilot study process from the initial stage of drafting of interview question to the final phase of finalized version of the interview questions.

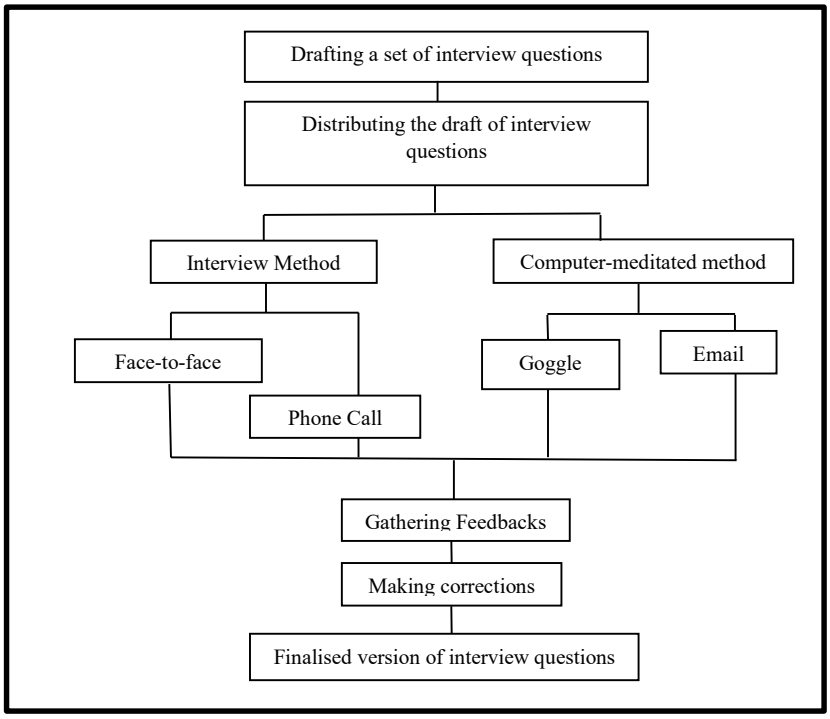

Figure 3: Pilot study process

4. Results and Discussion

This chapter explain and explores the results of the research obtained from the interview sessions and were discussed to answer the objectives of this research.

4.1 Results

The results are based on the analysis of the data obtained from interviews questions posed to the respondents which is the Contractor of Grade 7 in construction industry. The selected respondents consisted of engineers and quantity surveyor who worked around Kota Kinabalu, Sabah.

(a) Result of respondents' background

Table 2: Demographic profile of the respondents

Respondent (R)	Academic Level	Occupation	Work Experience	BIM experience in work practice	Knowledge in BIM	Types of projects involved
R1	Bachelor's Degree	Quantity Surveyor	1-3 years	3 years	Yes	Buildings
R2	Bachelor's Degree	Engineer	7-9 years	None	Yes	Infrastructure
R3	Bachelor's Degree	Quantity Surveyor	1-3 years	3 years	Yes	Buildings
R4	Bachelor's Degree	Engineer	1-3 years	None	Yes	Buildings
R5	Master's Degree	Quantity Surveyor	4-6 years	4 years	Yes	Buildings

(b) Result of problems of Collaborative Communication (CC) in the current practices among the project participants in construction projects

The problems of collaborative communication (CC`) that are normally seen in the construction projects consist of the poor CC that affected the cost and time of construction projects, non-standardized information sharing, low level of CC during decision-making process, and lack of advanced technology supports. Result of analysis about the problems of CC were shown in Table 3 to Table 6.

Table 3: Practice of poor CC that can affected the cost and time in construction projects

Respondent (R)	Opinion about how CC can contribute to cost and time overruns in construction projects
R1	Failure of contribution to efficient expertise
R2	Unclear instruction causing misinformation
R3	Misinterpretation during project planning causing unnecessary cost implied
R4	No proper coordination that leads to chains of problems
R5	Ineffective communication among stakeholders cause delay

Table 4: Effects of non-standardized information sharing

Respondent (R)	Effects of Non-standardized information sharing towards CC of project participants
R1	Misleading; Difficult to track record
R2	Informal; Only as an early notice
R3	Non-standardized information is not suitable for collaboration of different parties
R4	Causing miscommunications
R5	Risking the project participants' interest

Table 5: Effects of low level of CC during decision-making

Respondent (R)	Opinion about effects of low level of CC during decision making
R1	Increase in project duration
R2	Affects the decision-making process
R3	Decision making process is disrupted
R4	Conflicts in the planning process for manpower and resource utilization
R5	Construction project will not be seamless

Table 6: Lack of advanced technology supports

Respondent (R)	Opinion about how lack of advanced technology supports affect the CC among project participants.
R1	Requires longer time when using traditional method of CC
R2	Affects the immediate notice of amendments and discussion between other parties
R3	Information cannot be delivered immediately
R4	Accurate information cannot be delivered properly, increase in margin of error
R5	Virtual meeting between parties cannot be done during *Covid19*

(c) Result of benefits of practicing collaborative communication in Building Information Modeling (BIM) implementation for construction projects.

The second objective is achieved by identifying the benefits of practicing collaborative communication in Building Information Modeling (BIM) implementation for construction projects. The benefits consist of better visualisation of drawing, integrated collaboration and communication, BIM as single environment platform and BIM increases the productivity of construction projects. Result of analysis about the benefits of practicing collaborative communication in Building Information Modeling (BIM) implementation for construction projects were shown Table 7 to Table 10.

Table 7: Better project visualisation of BIM

Respondent (R)	Opinion about how better visualisation of BIM helps to ease collaboration and communication between project participants
R1	Calculation process is more accurate
R2	End product is clearly shown
R3	Clearer information delivered
R4	Construction model can be perceived easily
R5	Facilitate personnel to execute work as per Client's request

Table 8: Integrated collaboration and communication

Respondent (R)	Opinion about how BIM helps to improve information exchange process between project participants compare to traditional method of CC
R1	More conductive
R2	Assists in cross-checking
R3	Overall details are clear and uniformed
R4	Information can be produced in graphical manner
R5	To achieve integrated CC in both BIM and traditional method efficient communication is needed

Table 9: BIM single environment platform

Respondent (R)	Opinion about how BIM as a single environment platform helps to improve the quality of the project.
R1	Organized information, easier access
R2	Minimize discrepancies
R3	Improved quality of information
R4	Reduce clash of services on site
R5	Improves the understanding towards same project's goals

Table 10: BIM-based CC increase productivity of construction projects

Respondent (R)	Opinion about how BIM-bassed CC increase productivity of construction projects
R1	Ease work complexity
R2	Improves discrepancy checking, cross checking, information (changes notification) and data storage
R3	Decision making can be determined faster
R4	Work is coordinated
R5	Insufficient manpower will affect the BIM

(d) Result of potential ways to enhance CC with challenges in BIM implementation for construction projects

Table 11: Potential ways for BIM implementation to improve CC in construction projects

Respondent (R)	Opinion about the potential ways for BIM implementation to improve CC in construction project
R1	Compulsory of BIM implementation in contract document
R2	Training, workshops, *Webinar*, education, and exposure
R3	Subsidies from Government
R4	Conduct seminar and promote BIM extensively (implementation through Government project)
R5	Focus on investing technologies tools for online interaction

4.2 Discussions

This section discussed about the analysis of the research results that were obtained to answer the research objectives.

(a) Respondents' background

Based on Table 2, respondents for this research are divided into two categories consisting of two engineers and three quantity surveyors, respectively. Each of the respondents is categorize by R1, R2, R3, R4, and R5 in which R represents Respondent. Among all the respondents, 2 respondents have the most exposure in the construction industry in term of working experience. R2 have around 7-9 years of working experiences as an engineer. R2 experiences in the industry also involved in infrastructure projects. R2 highest education level is bachelor's degree. The second respondents with the most exposure in the industry is R5 with 4-6 years of working experience. R5 highest education level is master's degree. R5 works as a quantity surveyor that involves with building projects. The remaining respondents (R1, R3, and R4) have similarities in term of the working experience in the industry, highest education level, and project involves. The working experience for this group is 1-3 years in building projects. The highest education level is bachelor's degree. However, R1 and R3 worked as a quantity surveyor while R4 work as an engineer. Moreover, the years of BIM experiences and knowledge were also assessed during the interview. Based on the findings, all the respondents have knowledge in BIM. However only R1, R3 and R5 have BIM experience in their current work practices. R1 and R3 each have 3 years experiences of using BIM in their work practice while R5 have 4 years experiences in using BIM. These findings validate that the respondents interviewed were suitable for the research.

(b) The problems of current practices in construction projects among the project participants regarding collaborative communication.

- ***Practice of poor CC*** - Based on the result in Table 3, R1 and R5 have similarity in their opinion about the practice of poor CC towards the productivity of the construction project. They linked the practice of poor CC in the construction projects especially during decision-making process will obstruct the knowledge sharing between the project participant during the construction process. This will affect the productivity of the project and led to time overruns. This statement has similarity with Reed & Knight (2010), in which their reported that lack of adequate communication will obstruct communication and causing insufficient knowledge transfer. In contrarily, R2, R3 and R4 associate practice of poor CC will contributes to many other problems in the construction project. They claimed that the practice of poor CC and lack of proper coordination especially during project planning will cause misinterpretation of project's objectives during the construction process. This misinterpretation will cause unnecessary cost incurred that lead to increase in project cost. This statement was supported by Tai *et al.* (2009) whereas they stated that a weak organizational structure of construction team will cause problems in collaboration and communication in construction projects.

- ***Non-standardised information sharing*** - Based on the overall data analysis of non-standardised information sharing in Table 4, the respondents agrees that the non-standardised information sharing was a problem in the current practice of CC among project participants. However, there are still a slight difference in terms of their perception of how the non-standardised information sharing affect the construction project. R1, R2, and R3 relates the effect of non-standardised information sharing the current practices of CC was not an effective method to be used in the collaboration and communication between different stakeholders in the construction project especially when it involves the document and information sharing between different project participants. This statement was supported by Tai *et al*. (2009) in which they reported that the lack of uniformed standards for construction information can cause communication problem especially in large-scale projects. In contrast, R4 and R5 stated that the without a standardised information sharing in the construction project, it will cause adversarial relationship between the project participants because of miscommunication. This was supported by previous research by Spang & Riemann (2014) where they associate the disagreement among stakeholders because of CC problems cause dispute and adversarial relationship.
- ***Low level of CC during decision-making*** - Based on the data analysis in Table 5, all the respondents relate the effect of low level of CC during the decision-making process with the efficiency and productivity of the construction project. According to them, low level of CC during decision-making will interrupt the construction process and affected the team member. They confirmed that this problems of low level of CC will affects the construction project duration because of delay in the decision-making. R1 stated that there will be a risk of paying the cost of damages caused by the delay. Moreover, according to R4, without an effective CC, the construction team will face delay in decision making for the project planning. In some cases, this delay in decision making causing conflicts in the planning whereas Contractor unable to provide manpower and resources efficiently. Past research by Koushki *et al.* (2005) and Tabtabi, (2002) also confirmed the statements by the respondents where they reported that the low level of CC can cause delays in the construction projects.
- ***Lack of advanced technology supports*** - Based on the data analysis of effect of lack of advanced technology supports in the current practices of CC in the construction project shown in Table 6, the similarity found was in term of time taken for CC process between different parties. Respondents claimed that the lack of advanced technology supports affected the efficiency of the information and communication flow. The inefficiency of the information flow caused delay in two areas of construction process which are the information sharing or transfer among the project participants throughout the construction life cycle and immediate notification of work alterations between design team and construction team. It was also found that without advanced technology supports, project participants have to use traditional method of CC which was considered inconvenience as the paper documentation were required. Tai *et al.* (2009) in their study also confirmed that lack of advanced technology will cause problems related to collaboration and communication. In contrarily, R5 have a different perception when discussing about the problems of lack of advanced technology supports. R5 said that the use of advanced technology supports is important for CC between project participants because it can be the solution to replace the physical meeting in the event of force majeure that permits the parties to have a face-to-face CC.

(c) The benefits of practicing collaborative communication using Building Information Modeling (BIM) for construction projects.

- ***Better project visualisation*** - According to Goh *et al.* (2014), the BIM is beneficial in providing better visualization in the drawings and this will then improve the overall project quality. Based on the overall responses by the respondents in Table 7, R3, R4 and R5 have similarity in their answer. They agreed that with BIM better project visualisation it will benefits the CC of many parties in the construction project. This is because, BIM was beneficial for the project teams who is unable to

read and understand the information on 2D drawing to imagine and visualize it with the help of 3D model. This will lead to accurate project deliverance based on Client's request. This statement was supported by Samimpay & Saghatforoush (2020) where they reported that BIM contribute to better clarification of project concept that led to end product that satisfy the employer. Moreover, the respondents claimed that the 3D visualization will facilitate the project teams to receive and recognize the design in the shape of real building easier and this improve the coordination between the participants. This was also supported by Samimpay & Saghatforoush (2020) where they reported that BIM increase coordination and integration among design, construction, and logistics team. Additionally, BIM also help to delivered more coherent information that is not able to achieve when using 2D drawings where information shown is insufficient especially during construction work (Goh *et al*., 2014). However, R1 and R2 have different opinion about better project visualisation of BIM. They claimed that better visualisation of BIM benefits more on their work process instead of in the CC.

- ***Integrated CC*** - The benefit of BIM for an integrated CC have shown three different perceptions among the respondents which consists of facilitate the work process of the project participants, improving the quality of the information and documentation in construction project, and as a tool for cross-checking as shown in Table 8. R1 relates the integrated CC of BIM with the ability to ease the work process during building work measurement as the models can be calculated directly from the BIM model. This statement is similar to what were reported by Goh *et al.* (2014), in which BIM is a suitable platform for BQ and taking-off work during documentation phase. Next, for the perception of improving the quality of information and documentation in construction project, two respondents (R3 and R4) show similar answer. According to R3, BIM can help the participants in acquiring the overall view of the project details because information provided by BIM clear and uniformed. Moreover, the response from R4 also showed that the ability of BIM to produce graphics information helps project participants to identify the outcome of the design and project planning. The respondents' statement was confirmed by past research reported by Van Berlo & Natrop (2015) where they stated that the BIM was used to generate drawings adapted to the task of onsite workers. This is to provide site workers with all the information they needed for the tasks. As a result, the BIM approach has successfully established an effective communication tool between the site office management and construction workers. R2 and R5 have the same perception that traditional method of CC is still consider significance in their current work practice compared to BIM-based CC. However, the third perception of how integrated CC of BIM benefits in construction project was obtained from R2. R2 suggested that BIM implementation can be used as a method to validated or cross-checking work done by using traditional method.
- ***BIM as a single environment platform*** - Based on the overall respondents' statements in Table 9, it is seen that the respondents agreed that BIM single environment platform helps to improve the quality of information in the CC among project participants in the construction projects. R2 claimed that it could lower the risk of inaccuracy on the design which benefits in minimising discrepancies. According to R5, BIM also help in information sharing and improves the comprehension of the project participants about the project goals. R4 also agree that BIM can help in coordinating all the work in the construction site and hence minimize the conflicts of construction works. This is similar to past researcher by Goh et al. (2014), where they reported that BIM helps to facilitate management process in construction industry and improves the communication among project participants that are centralised within the BIM system. In addition, R1 and R3 further indicated that the BIM function as a single environment platform is beneficial to ensure information is well organized, to improve the quality of information and allow easier access for information by all the parties involves in the project. The respondents' statements were validated by Hewage & Ruwanpura (2015), whereas they claimed that the BIM implementation has overcome the issues of onsite participants who are unable to obtained material management, work demo and updated drawings easily from the design team.

- ***BIM-based CC*** - Based on Table 10, almost all the respondents agreed that BIM-based CC improve the productivity of construction project. R1 and R3 have similar perception about how BIM can increase the productivity of the construction project. As the BIM function is based on collaborative software, the decision-making process can shorten and therefore the construction planning can be determined more effectively. Moreover, R2 prefers real time face to face discussion during decision making process because it is more efficient. Even so, R2 clarify that BIM still can be used for discrepancy checking, cross checking, information notification when there are changes, and data storage. Furthermore, R4 suggested that BIM is the best solution to fix the issues regarding the complex and confusing coordination of construction work. With BIM, there will be no issues involving work clash/collision on-site. These statements were supported by Kiviniemi (2013), where BIM has become a tool to enable higher productivity by improving the management of information in construction projects where it enables more collaboration within the fragmented AEC industry. In contrast, R5 linked the current situation of pandemic as an issue of productivity in the construction industry as many organizations must reduce their manpower to follow the Standard Operation Procedures (SOPs). Although BIM is implemented in the construction, without sufficient manpower it will obstruct the decision making and information process.

(d) The potential ways to enhance collaborative communication with challenges in Building Information Modeling (BIM) implementation for construction projects.

Objective 3 was achieved by obtaining suggestions of potential ways of BIM implementation in improving CC in construction projects from the respondents. Based on the overall answers by respondents as shown in Table 11, three different answers were obtained. R2, R3, and R4 suggestions mainly focusing on the Government as the key industry drivers for the BIM implementation. R2 and R4 have similar suggestions on how to implement BIM in the construction projects. According to them, it is important to improve the BIM knowledge among the industry players. This can be done by organizing training, workshops, webinar, and seminar especially about introduction of BIM, functions and how to utilize it. The Government also have an important role in encouraging the industry players to implement BIM. The Government could promote BM through its implementation in Government's projects. In addition, R3 suggested that with subsidies from the Government will help in promoting BIM implementation. On the contrary, R1 and R5 have similar opinion where they suggested that the industry players play an important role for BIM implementation to improve CC in construction projects. The suggestions for BIM implementation made by R1 is by making the BIM implementation in construction project as compulsory. This can be done by stating the requirements in the contract document. This way, the involved participants will have to implement it to avoid the breach of contract. Moreover, according to R5, the industry players should also focus on investing and buying technologies tools for online meeting. This is to facilitate the collaboration and communication of project participants when face to face interaction cannot be done.

5. Conclusion

This section discussed the conclusion of the research findings and research limitation. Moreover, conclusions and recommendations are made comprehensively for the purpose of good research effectiveness. At the end of this section, suggestions are also included for the purpose of developing further research on this topic. The first objective of this research was assessed in four aspects of problems in the current practices of CC which consists of practice of poor CC, non-standardised information sharing, low level of CC during decision making and lack of advanced technology supports. The respondents described clearly about the problems in the current practice of collaborative communication among project participants in the construction projects. The practice of poor CC was determined to obstruct the knowledge sharing between project participants in the construction project and hence affects the productivity of projects. Moreover, the misinterpretation of project's objective

because of poor CC contributed to other construction problems that affect the cost and time. For the next aspect, it was determined that the non-standardised information sharing practice was not effective to be used in the current practice of CC especially when it involves the process of document and information sharing between various parties. In addition, non-standardised information sharing contributed to adversarial relationship between other stakeholders because of miscommunication. Besides that, the effect of low level of CC during decision-making process was identified as the factor that affected the efficiency and productivity of construction projects. The conflicts between the Client-Contractor were also confirmed as a result from the slow decision making of the Client. Apart from that, it has been recognised that the lack of advanced technology supports in the current situation of COVID19 pandemic will contribute to CC problem between project participants.

The second objective of this research was assessed in four aspects of the benefits of using Building Information Modeling (BIM) for CC which consist of better project visualisation, integrated collaborative communication, BIM as single environment platform, and BIM-based CC. The respondents showed positive responses of BIM as the tool for collaborative communication. Better project visualisation of BIM was confirmed to be beneficial towards the collaboration and communication of many parties in the construction project. This is because better project visualisation of BIM contributes to better understanding of the project concept that led to success of the end product to satisfy the Client. Besides that, the 3D visualisation of BIM assisted the various project teams to interpret the same information of the construction project. Integrated CC of BIM was figured to contribute to three benefits among the industry player which consist of facilitated the work process, improving the information and documentation in construction project, and a tool for cross-checking. Next, BIM single environment platform was also accepted as beneficial in the CC among project participants in construction project. Owing to the fact that the BIM single environment platform helps to ensure information is well organized, to improve the quality of information and allow easier access for information by all the parties involves in the construction project. As a result, this minimizes the risk of inaccuracy and discrepancies, improves the understanding of project participants, and coordinate the work in construction site to mitigate conflicts in work process. Finally, it was seen that the BIM-based CC have contributed to the increase productivity of construction project. The improvement in the productivity of the construction project with BIM implementation can be achieved in term of shorter time for decision-making process, information notification for work alteration, fixed the issue of complicated coordination of construction work. However, an issue was found in term of the application of BIM in the current situation of COVID19 pandemic, whereas the reduction of manpower was reported has affected the productivity.

Additionally, 3 Objective was assessed in term of the potential ways to enhance CC with challenges Building Information Modeling (BIM) implementation for construction projects. Two important parties which are the Government and the industry players have been identified as the key to implement the BIM in construction projects to improve collaborative communication. The Government have two crucial roles to help in BIM implementation which are improving the BIM knowledge of among the industry players and encouraging the industry players to implement BIM. To improve the BIM knowledge, respondents suggested that the Government to organize training, workshops, webinar, and seminar especially about introduction of BIM, BIM functions, and BIM utilization. Next, to encourage the readiness and openness of industry players to implement BIM, Government could promote BM through its implementation in Government's projects and with subsidies from the Government. Conversely, industry players roles to allow for the BIM implementation in construction project are by making the BIM implementation in construction project as compulsory in the contract document and focused on investing and buying technologies tools for online collaboration and communication especially during the force majeure events.

The research data only focused on the issues of collaborative communication, benefits, barriers, and suggestion for Building Information Modeling (BIM) implementation in construction projects. To see

the continuity of this research, further research could be done in the future about how to utilize Building Information Modeling (BIM) with the barrier of lack of manpower or resources in the project management during COVID19 pandemic.

Despite the obstacles and constraints faced by the researcher while conducting this research, the data obtained from the respondents clearly shows that the successful interview were done because of the respondent's willingness to collaborate with the researcher for the purpose of studying the issue regarding collaborative communication (CC) and Building Information Modeling implementation (BIM). The current situation of COVID19 does not become the barrier for the process of data collection by the researcher because the technology is being utilized for the purpose of ensuring the interview session doable. Furthermore, this research is expected to be beneficial towards the construction industry players as well as the academia parties. This research was significance to give the industry players insight about the problems of current practice of collaborative communication (CC) that are faced by the project participant in construction project. It promotes awareness about BIM as the CC tools as well as towards improving the collaborative communication in the construction projects. Finally, this research was expected to be beneficial towards the knowledge improvement on the BIM aspects and provide basis for further research on BIM and project management.

Acknowledgement

The authors would like to thank Faculty of Technology Management and Business, Universiti Tun Hussein Onn Malaysia for its support in completing this research.

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