APPLICABILITY OF BUILDING INFORMATION MODELING (BIM) FOR MINIMIZING DISPUTES ARISING FROM PROJECT TEAM DIVERSITY

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DECLARATION

I declare that this is my own work and this dissertation does not incorporate without acknowledgement any material previously submitted for a Degree or Diploma in any other University or institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text. Also, I hereby grant to University of Moratuwa the non-exclusive right to reproduce and distribute my thesis/dissertation, in whole or in part in print, electronic or other medium. I retain the right to use this content in whole or part in future works (such as articles or books).

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I dedicate this piece of research to my beloved family

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Abstract

Complexity of construction industry makes it inevitable to avoid disputes among project team members. Diversified nature of team members is identified as a main source of disputes which impose negativity to projects. Even though there is a visible connection between BIM implementation and dispute minimization, people tend to refuse accepting this valuable technology. Therefore, the research is mainly focused on identifying the applicability of BIM technology to minimize disputes within construction projects that arise due to diversified nature of team members. This research aim was approached through a qualitative research strategy by collecting data from qualitative observational study in the form of desk research and semi-structured interviews conducted with industry experts. The qualitative data was analyzed using content analysis to develop a conceptual framework which directed the study towards its aim. The research findings exposed encouraging team work; establishing a vision and providing goals formed by a central scientific idea; creating good communication within project teams; engaging qualified and experienced personnel; increasing levels of trust within the team; establishing effective problem solving mechanisms; and encouraging intellectual disagreement as the main causes of disputes that arise due to diversified nature of team members. Moreover, research disclosed the main techniques that can be used to implement the each identified main methods of dispute minimization. Accordingly, a conceptual framework was developed to identify the applicability of BIM technology in minimizing disputes among project team members. Additionally, the research findings were validated through expert opinions in order to make the outcome more reliable. The developed conceptual framework provides a basis for decision making in initial stage of building construction projects where decision for adopting BIM technology emerge. Moreover, further research directions can be suggested towards the areas such as concerning a different context for the same research problem and using different units of analysis.

Key words: Team diversity, Disputes, Conflicts, Dispute minimization, BIM (Building Information Modeling), Construction Project Team

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LIST OF ABBREVIATIONS

Abbreviation	Description
AEC	Architecture, Engineering and Construction
BIM	Building Information Modelling
CAD	Computer Aided Design
CDE	Common Data Environment
IOT	Internet of Things
LOD	Level of Development
QS	Quantity Surveyor

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CHAPTER 01

INTRODUCTION

CHAPTER 1
INTRODUCTION

1.1 Background Study

Construction industry can be identified as a very complex, high-risked, multiparty business where participants with different views and knowledge work together (E. Cakmak & Cakmak, 2014). According to Tolson (2013); and Fawzy and El-Adaway (2011), conflicts, claims and disputes in construction industry are unavoidable due to various reasons and these disputes inevitably bring many challenges and legal issues to take into consideration. Every construction project confronts conflicts and disputes which are considered as destructive events occurred in different stages of a project's development cycle mainly affecting the project's completion, cost, and performance (Zack, 1995).

Conflicts are such situations which occur due to discrepancies between values or aims to be achieved (Rauzana, 2016). As identified by Semple, Hartman and Jergeas (1994), considerable amount of conflicts exists within the construction industry due to its complexity, multiparty involvement and high-risk. Disputes are referred to the extended disagreements on unsettled claims and conflicts (Kumaraswamy, 1997). As identified by Cheung and Yiu (2006), disputes in construction can be attributed to the conflicting interest of the large number of participants. Disputes which arise due to such conflicts can impose a severe impact on successful completion of a construction project (Cheung & Pang, 2013).

When considering the actual meaning of the term 'dispute', Fenn, Lowe and Speck (1997) stated that some authors have failed to differentiate the meanings of terms disputes and conflicts. According to Younis, Wood, and Malak (2008), "the definition of dispute is itself a matter in dispute" (p.729). Diekmann and Girard (1995) identified dispute in construction industry as any contract issue or disagreement that must be settled beyond the jobsite management. As per Zack (1995), some recognize disputes as simple disagreements, whilst others believe they are the consequence of rejecting a claim.

According to Kumaraswamy (1997), although the term ‘dispute’ is defined in many different ways in literature, best suited definition for construction industry can be identified as the situation where there is a rejection by a party of a claim or assertion made by the other party and that rejection is not accepted. Therefore, in due course, a dispute related to the construction industry can be identified as a disagreement over a decision which arises after an evaluation of a contractual matter.

As identified by Kumaraswamy (1997), minimizing disputes which originate from conflicts and claims is essential for construction projects. According to Ashworth (2012), disputes can lead to squandering time and money as well as ruining well established relationships. Disputes in a construction project can influence on all stakeholders in the construction industry (Marzooq, 2015). Thus, it becomes important to focus on minimizing disputes to reduce its negative effect on the successful completion of a construction project.

According to Semple et al. (1994), although the influence of disputes over the construction projects have been identified, the fundamental causes associated with disputes are not well understood. However, Cheung and Pang (2013) in their research have identified risks, uncertainties, and behavioral factors as some of the notable dispute sources. According to Kumaraswamy (1997), construction conflicts arise due to sources such as the contract, project team and other external factors. Further, Marzooq (2015) has stated that there are five primary causes of construction disputes such as modifications made to the standard conditions of the contract; lack of understanding of parties about the main concerns in the contract; poor documentation; regulation and legislation changes; and cultural influence on the performance of the parties involved in the contract. As per Diekmann, Girard and Abdul-Hadi (1994), construction disputes are generated by people, process and product. As identified by Mitropoulos and Howell (2001) through their research, project uncertainty, contractual problems and opportunistic behavior are the basic three factors which influence on originating disputes. As per the research findings of S. Mitkus and Mitkus (2014), unsuccessful communication, unfair behavior of the parties to a construction contract agreement and psychological defense mechanisms are the main causes of disputes between parties.

Therefore, it is obvious that the personal conducts of the project team due to the diversified nature of the members is a considerable aspect among the various causes of disputes which need to be given a closer attention. Accordingly, a necessity arise to explore the composition of a project team. As per Chua, Kog and Loh (1999), project manager, client, contractor, consultants, subcontractor, supplier, and manufacturers can be identified as the key players of a construction project team.

When it comes to controlling disputes among team members, Nelson (1995) has identified direct approach; bargaining; enforcement; retreat; and de-emphasis can become more effective. Further, it is believed that disputes between two parties can be minimized by understanding own business interests; understanding other party's interests; acquiring information; examining alternatives and recognizing egocentric bias (Shapiro, 2012). Therefore, as revealed by the empirical data, disputes can be minimized using different actions. These actions can be implemented using various techniques. For instance, according to Ito (1998), computer systems such as CAD system, analytical systems, and simulation systems are used for acquiring information in construction projects which ultimately controls disputes. Therefore, it becomes important to examine the existing techniques of dispute minimization, including new technologies, to identify the most effective method to adopt.

Exploring about new technologies used in the construction industry drives the attention towards distinguishing BIM which can be used to simulate a construction project in a computer-generated environment (Eastman, Teicholz, Sacks, & Liston, 2008). According to Construction Project Information Committee (CPIC, 2011) BIM is a digital representation of physical and functional characteristics of a building with the ability to create a common and reliable source of information providing a base for decision making throughout its life cycle. Further, an entire building life cycle can be demonstrated with this model (Bazjanac, 2006). Accordingly, BIM assists in retrieving information such as quantities and properties of materials in an efficient manner; and proper documentation with interrelated documents (Khemlani, Papamichael & Harfmann, 2006). Moreover, BIM captures reality of a project by providing and compiling all the required inputs which cannot be interpreted in a paper for commencing a construction work, and shares in a model (Ball, 2018).

As identified by Associated General Contractors of America (AGC, 2005), BIM is a data-rich, object-oriented, intelligent and parametric digital representation of the facility which allows to extract views and data appropriate to various users' needs and analyze to create information that can be used for decision making. Therefore, it can be observed that BIM is a gradually instigating advantageous technology with a potential to provide effective encouragement for implementing existing dispute minimizing techniques in the construction industry.

1.2 Research Problem

Disputes among project team that arise due to the diversified nature of the members can be minimized using various techniques available in the construction industry. Although there is a visible connection between dispute minimization techniques among project team members and BIM technology, it has not yet been theoretically confirmed. Thus, ascertaining the applicability of BIM technology to minimize disputes that arise due to team diversity requires a thorough consideration. Hence, this research intends to fill that research gap by studying and establishing the applicability of BIM technology to improve dispute minimization among team members of building construction projects that arise due to team diversity for reducing negative effects of disputes on a project.

1.3 Aim and Objectives of the Research

Aim

This research mainly focuses on identifying the applicability of Building Information Modeling (BIM) for minimizing disputes that arise due to diversified nature of the team members in construction projects.

Objectives

- ✓ To determine the main sources of disputes among project team members that arise due to team diversity.
- ✓ To examine the available methods to minimize disputes that arise due to diversified nature of the project team members.
- ✓ To identify the existing techniques used to implement methods of minimizing disputes caused by team diversity.
- ✓ To develop a framework to recognize the applicable BIM features and tools that improves existing techniques for minimizing disputes resulted by diversified nature of team members of construction projects
- ✓ To confer recommendations on applicability of BIM technology for minimizing disputes among construction project team members that arise due to team diversity.

1.4 Methodology of the Research

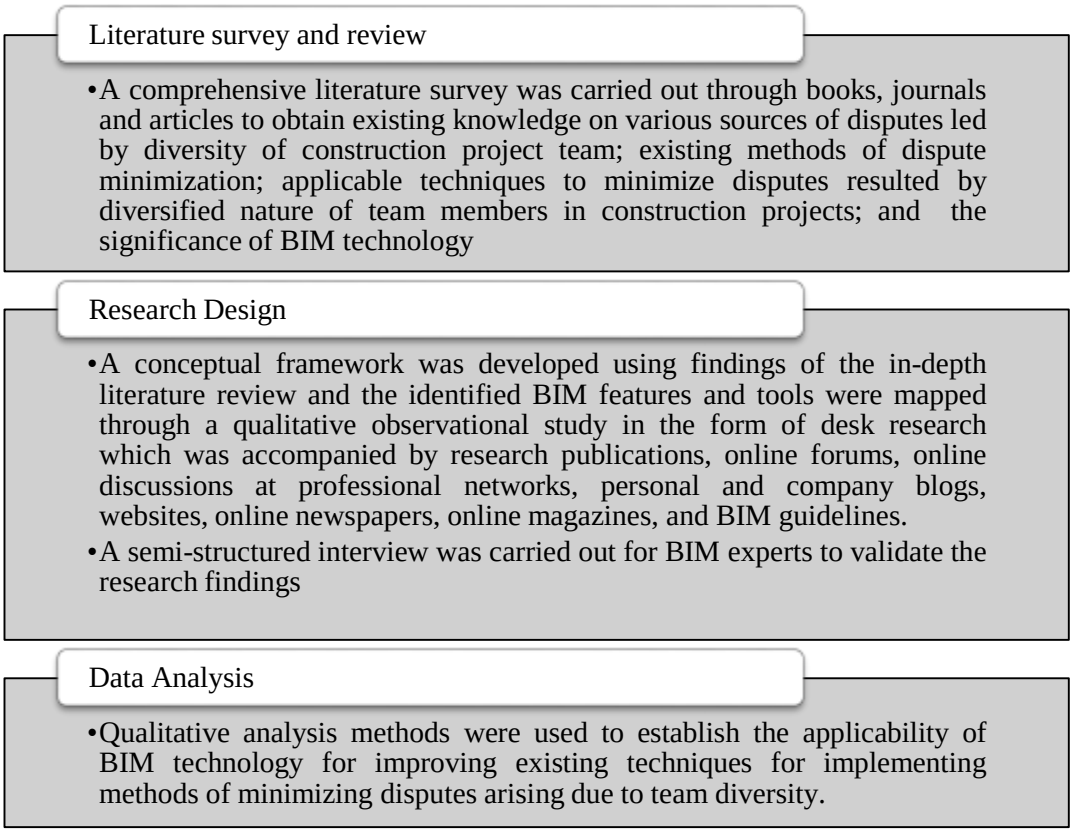

Figure 1.1: Research methodology

1.5 Scope and Limitations

Since BIM technology is currently limited to the building construction projects, this research is limited only for building construction industry. Further, only the people who are directly involved to the project are considered as team members of a project to identify the disputes led by the diversified nature of team members. Additionally, BIM level 2 is referred as BIM technology within the research to avoid confusion while mapping BIM features in to the developed conceptual framework of the study.

1.6 Chapter Breakdown

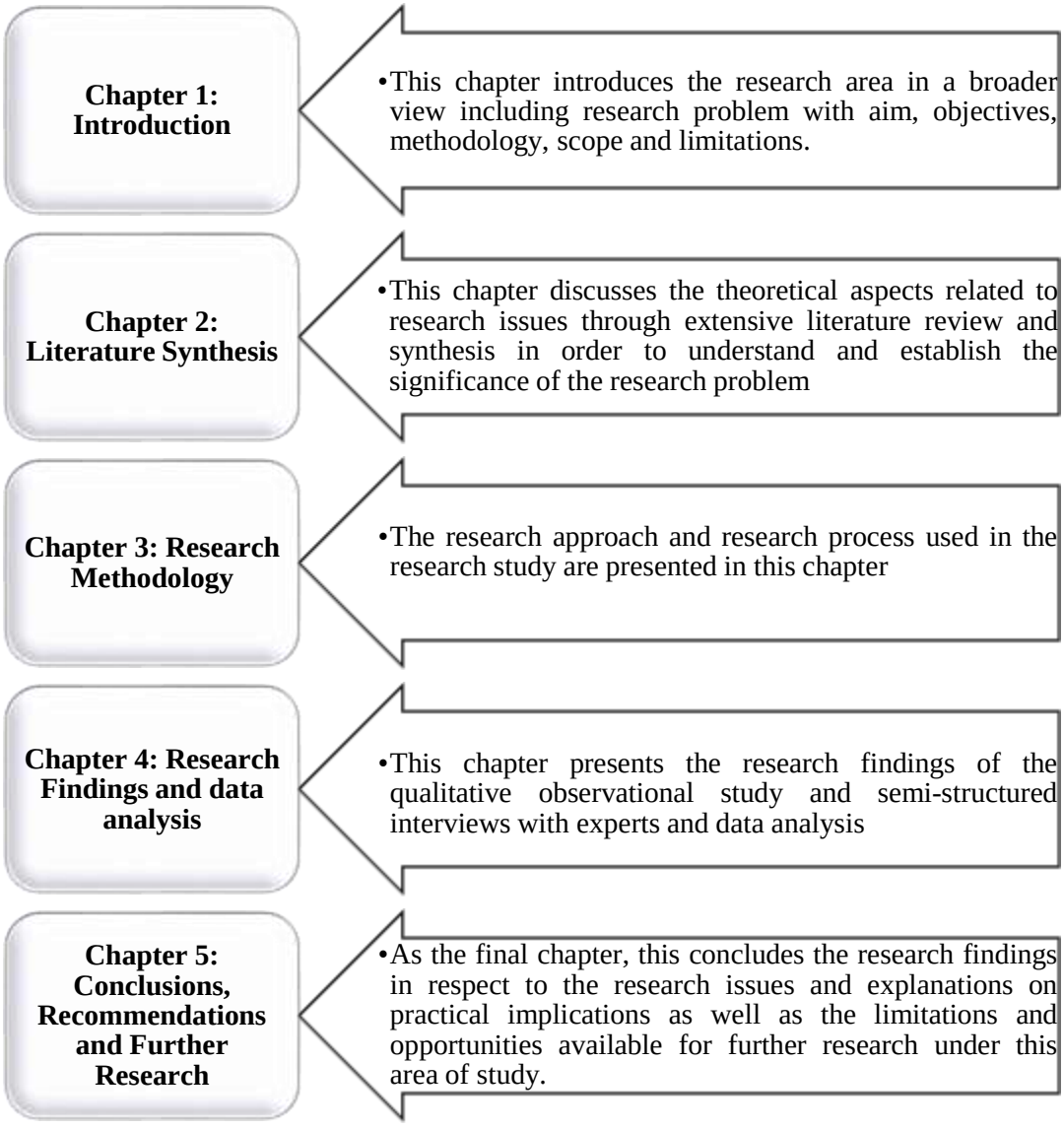

Figure 1.2: Chapter breakdown

CHAPTER 02

LITERATURE REVIEW

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction

Chapter one has provided a brief overview to the research and the literature review chapter is primarily focused on identifying the research area through an in-depth study of the already published literature. Further, it synthesizes the existing knowledge level on the study area to provide a better understanding of the research problem.

The literature review has been commenced with a brief introduction to the construction projects where there is a visible negative impact due to disputes among team members of a project. Then the terminology used in the construction industry to refer disputes were identified; and the definitions and existing relationships among disputes, conflicts and claims were clarified to avoid confusions while understanding the study. In order to cover the first objective of the study, the main sources of disputes among project team members that arise due to team diversity have been identified using the findings of different researchers. Further, existing methods of minimizing disputes among team members that are led by diversified nature of the team and available techniques in the construction industry for implementing such methods have been identified with the intention of achieving the second and third objectives of the study. Finally, the literature review is used to identify the features and significance of BIM technology. Literature has been synthesized as much as possible to formulate a solid base for the research problem.

2.2 Construction projects

According to G. Sweis, Sweis, Hammad and Shboul (2008), construction industry can be identified as a considerable contributor of employment and wealth of a country's economy. Projects in construction industry are significantly complex and involve many uncertainties (Baccarini, 1996). In their research, Baiden, Price and Dainty (2006) have identified that construction industry fails to deliver projects successfully due to various reasons such as failure to have an effective project team.

As identified by Sanvido, Grobler, Parfitt, Guvenis, and Coyle (1992); and Wang and Huang (2006), the construction project team can be considered as one of the main factors that directs a project towards its success. Therefore, it is obvious that a construction project team becomes an important factor when it comes to the successful completion of a construction project.

2.2.1 Construction project team

As identified by Odusami, Iyagba and Omirin (2003), professionals such as project manager, architect, structural engineer, services engineer, quantity surveyor and contractors can become a part of a construction project team. Chua et al. (1999) revealed that project manager (PM), client, contractor, consultants, subcontractors, suppliers and manufacturers are the main key participants in a construction project team. According to Acharya, Dai Lee, and Man Im (2006) project team involves four main parties as owners, designers, constructors and the labor force. Further, according to his findings, these major parties work towards the project objectives with their own interest where owner is focused on the quality and economic aspect of the project; designer is interested in converting the owner's requirements into specific and detailed directions through drawings and specifications by prioritizing the creativity or aesthetics rather than cost and time; contractor is governing the time, minimum cost to complete the structure; and labour force is obligated to use their skills and efforts to create a reality through implementing directions given in plans and specifications. Therefore, it can be observed that a construction project team comprises various parties with different perceptions.

Project success can be achieved by proper collaboration of the project team (Baiden & Price, 2011). Moreover, as revealed by Chua et al. (1999), participants of a project is a significant aspect that cannot be ignored. However, as identified by Smith, Merna and Jobling (2014), there is no involvement of perfect team members in a construction project. According to Project Management Institute (PMI, 2004), the people in a construction project team have different interests which may lead to conflicts.

Further, as stated by Mohsini and Davidson (1992), project performance in construction industry can be negatively affected by inter-organizational conflicts in a construction project. Therefore, it is obvious that disputes can be expected within an imperfect construction project team.

2.3 Claims, conflicts and disputes

When trying to establish the relationship between construction project team and disputes, it is important to obtain a clear understanding of the meaning used for the terminology in the construction industry. As identified by Kumaraswamy (1997), understanding meanings of conflicts and claims becomes essential for minimizing disputes that arise from unresolved conflict and claims in construction projects. As revealed by Fenn et al. (1997), some researchers do not differentiate the terms disputes and conflicts. Further, according to Cheung et al. (2006), the terms dispute and conflict are used almost as synonymous in the construction industry which is unacceptable. Therefore, it becomes important to discover the relationship among the terminology to proceed with the study.

2.3.1 Relationship among claims, conflicts and disputes

As identified by Younis et al. (2008), a dispute occurs when one party disagrees for the rejection of a claim by the other party making dispute an amalgamation of a claim, a rejection and a non-acceptance of the rejection. Moreover, as per Merrills (2017), a dispute can be defined as a "specific disagreement concerning a matter of fact, law or policy in which a claim or assertion of one party is met with refusal, counter-claim or denial by another" (p.1). Hellard (1987) revealed that construction dispute is the opposition of interests, values or objectives and as per Spittler and Jentzen (1992), construction disputes are associated with differences in perspectives, interests and agenda of human beings. Acharya et al. (2006) identified conflicts as a negativity which occurs in the existence of an incompatibility of interest.

Further, Collins (1995) has discovered that conflicts can be identified as a considerable disagreement and argument on a significant aspect as well as a significant difference between two or more beliefs, ideas or interests.

According to Barrie and Paulson (1992), claim can be recognized as a disagreement which arise as an extension of conflict that is generated to recover the loss. Based on the various research findings, the basic relationship among claims, conflicts and disputes can be demonstrated as in figure 2.1.

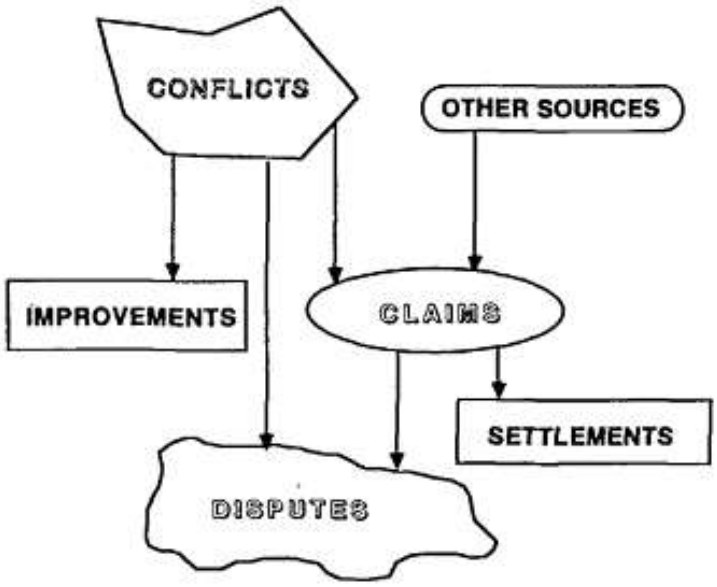

Figure 2.1: Basic relationship among claims, conflicts and disputes
Source: (Kumaraswamy, 1997, p.98)

According to the illustration given in figure 2.1, claims can be initiated by both unresolved conflicts and other resources. Further, disputes can be generated from unsettled conflicts as well as unresolved claims. When it comes to conflicts, they can either be resolved or become a dispute or a claim. Therefore, it can be observed that various relationships and different definitions with a merging effect have been established in the construction industry with regard to claims, conflicts and disputes. Hence, to avoid complexity and confusions, for the purpose of conducting this study, the meaning of dispute is extracted from the relationship where disputes are generated from claims and conflicts despite the terminology used in the literature. In other words, the study has focused only on the aspects where disputes have been formed by unresolved claims. Accordingly, when considering disputes, it becomes important to identify the motives for denying disputes in the construction industry which is elaborated in the subsequent subsection.

2.4 Impact of disputes on successful project completion

According to Cheung and Yiu (2006), the significance of dispute reduction is revealed by the numerous publications available under the construction industry. Disputes become a fundamental cause of preventing successful completion of a project (Merna & Bower, 1997; Rauzana, 2016). Further, as identified by Acharya et al. (2006), dispute is a considerable aspect which can affect the performance of the project participants. Disputes within a construction project can result in disruption of construction schedules, increasing project costs, and even adversely impact on the relationships among the project team (Sinha and Wayal, 2007). As per Cheung, Suen, Ng and Leung (2004), a dispute can lead to litigation proceedings which can be extremely expensive for the concerned parties. Moreover, disputes can result in attitudes with less friendliness, low trustworthiness and reduced respect which can adversely impact on the performance of a project team (Walton & Dutton, 1969). Further, in her research, Rauzana, (2016) has discovered that to achieve a successful completion of a project in terms of desired time, budget and quality, it is important to be aware of the causes of disputes.

Hence, it is evidenced that disputes can impose an unfavorable impact on the success of a project. Consequently, in order to minimize such negative impacts on the construction projects, the need of identifying the causes of disputes comes in to effect which is elaborated consequently.

2.5 Causes of disputes among team members arising due to team diversity

In order to act towards reducing the impact from disputes, it is essential to get an understanding of the causes of disputes among construction project team members that arise due to diversified nature of the team (Love, Davis, London and Jasper, 2008). As revealed by Horwitz, S. K. and Horwitz (2007), team diversity is identified in terms of different expertise, experiences, and perspectives of team members. According to Cheung et al. (2004), findings on causes of disputes have already reached the saturation point as many researches have undertaken their researches under this subject area.

Love et al. (2008) revealed that some literature available under the construction industry have identified the sources of conflicts and claims; and sources of disputes as similar. Therefore, it becomes obvious that the information from existing literature should be extracted based on the meaning despite the usage of terminology.

As identified by Cherns and Bryant (1984), construction project teams comprise with members who may be having conflicting interests. The disputes among construction team members are inevitable due to the difference in their interests (Butler, 1973). As revealed by Greenburg (2011), there are eight core sources that lead to a conflict between parties towards disputes due to the diversified nature of the team. These sources include 'facts' that can be identified as the information retrieved by people with different experience; 'definitions' which provides different meaning to terms; 'values' which depends on the person's perspective; 'signaling' which is used as an expression to show a person's emotions such as loath; 'failures of logic' which can be identified as having difficulties of understanding other's arguments; 'information processing methods' where people use different modes of communication which is not acceptable by all parties; 'default beliefs' which prevents people from considering other's opinions; and 'self-interest' which prevents accepting truth while defending the self.

As per the research findings of Cheung et al. (2006), the main source of disputes can be identified as the formation of clashes among the contractual parties. In their research, Langford, Kennedy and Sommerville (1992) have identified the main cause of disputes in all construction projects as the project team which is formed as a mini-society with complex interrelated relationships demanding corporation and collaboration. Moreover, as revealed by Gamero, González-Romá and Peiró (2008), disputes among team members can be initiated due to the assigned task or due to relationship conflicts among members. According to Barsade, Ward, Turner and Sonnenfeld (2000), relationship conflict is referred to circumstances where personal disagreements and incompatibilities exists. Task conflict can be identified in situations with disagreements among members in relation to the content of their decisions, tasks, objectives and procedures (Gamero et al., 2008).

Moreover, in their research, Rameezdeen and Gunarathna (2003) have identified the main cause of disputes within projects in construction industry as the communication gap among project team members. According to Cheung and Pang (2013), divergent interests of the team members of a construction project leads the conflicts and claims towards disputes.

Based on the literature findings from the research by Cheung et al. (2006), the main causes of disputes that related to the diversified characteristics of the team members can be identified as culture; communications; opposition of interests, values or objectives; difference in perspectives, interests and agenda of human beings; incompatibility of two (or more) people's (or groups') interests, needs and goals; lack of team spirit; misunderstandings; competitive/ adversarial attitude and dissimilar perceptions of fairness by the participants; and opportunistic behavior.

In his research, Kumaraswamy (1997) has illustrated the potential sources of construction disputes as in figure 2.2.

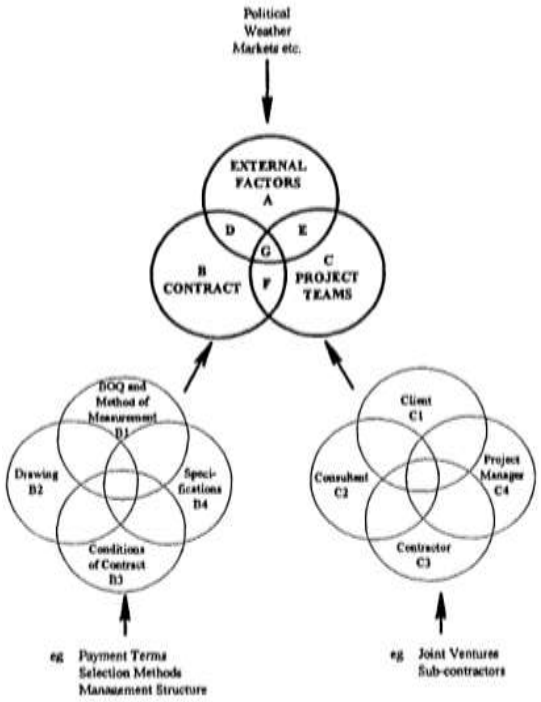

Figure 2.2: Potential sources of construction disputes
Source: (Kumaraswamy, 1997, p.97)

As demonstrated in the figure 2.2, the diversified nature of the project team can be recognized as a main source of construction disputes.

Further, from the research findings of Kumaraswamy (1997), adversarial (industry) culture; lack of competence of project participants; lack of professionalism of project participants; client's lack of information or decisiveness; unrealistic information expectations by the contractors; poor communications; personality clashes; and varied interests can be extracted as causes of disputes which are generated due to the diverse characteristics of the team members.

Further, in their research, Love et al. (2008) have also identified different characteristics of the project team as one of the main causes of disputes in the construction industry. Consequently, Love et al. (2008) identifies opportunistic behavior which is also known as the moral hazard of team members as the usage of a person's superior knowledge to take advantage on circumstances with the intent of full filling their own interests. Therefore, based on the findings of Love et al. (2008), opportunistic behavior of team members is again identified as a significant cause of dispute in construction projects. This can be demonstrated as in figure 2.3.

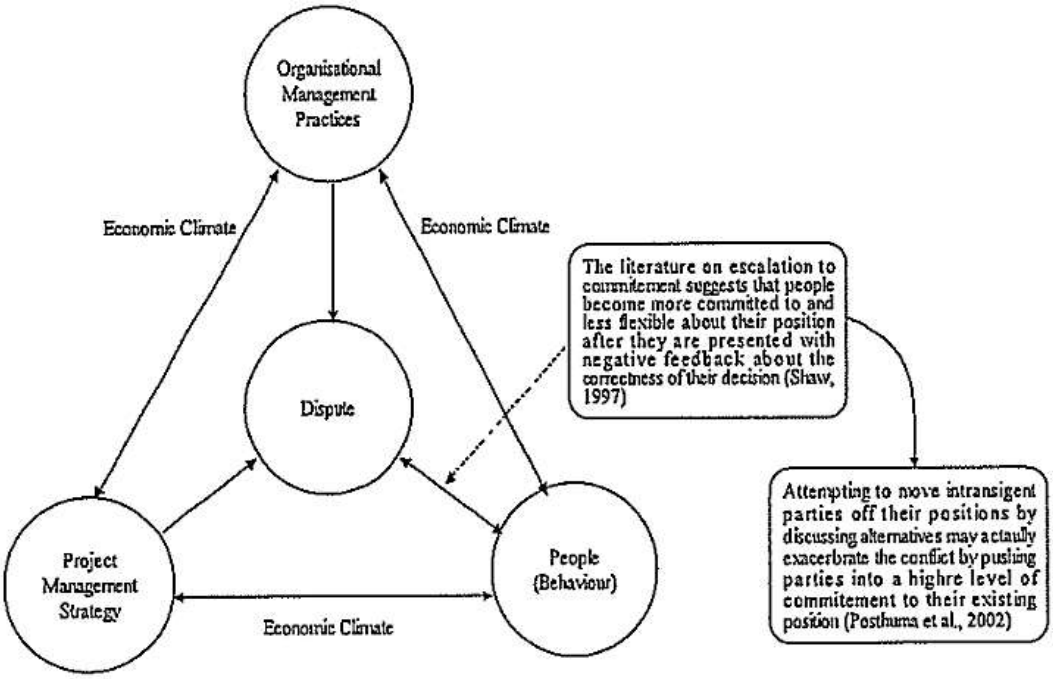

Figure 2.3: Constructs influencing disputes
Source: (Love et al., 2008, p.873)

Disputes among project team members can also be initiated from cognitions, behaviors, and emotions of the people involved (Garcia-Prieto, Bellard & Schneider, 2003). In their research, Cheung and Pang (2013) have recognized cognitive disputes as the collaboration issues that arise within the construction stage; behaviors as opportunistic strategies in construction claims where people would be seeking their own interests and benefits; and emotional disputes as the personal and interpersonal affective conflict among project team members.

As identified by Younis et al. (2008), disputes among team members can be initiated by uncooperativeness, slowness of decision making process, inadequate communication and influence from social and cultural factors. Moreover, disputes can become a result from lack of communication and lack of team spirit (Bristow & Vasilopoulous, 1995). Additionally, as revealed by Colin, Langford and Kennedy (1996), negligence can also be identified as a source of dispute among project team members.

In their research, Gardiner and Simmons (1998) have revealed that there are five main causes of disputes within a construction project which can be summarized and tabulated as in table 2.1.

Table 2.1: Disputes among project team members

Cause of dispute	Summary
Task interdependency	Conflict resulting from dependency upon others (e.g. for information, feedback, or completion of a task)
Organizational differentiation	Conflict due to different group of people perceiving the same thing differently
Values, interests and objectives	Conflicts arising from misalignment of personal goals with project goal
Tension	Conflict resulting from unresolved and mounting interpersonal tensions
Personal traits	Conflict escalation due to lack of understanding or inability to manage personalities encountered
Communication obstacles	Conflicts arising due to unresolved cognitive differences formed by different levels of experience

Source: (Gardiner & Simmons, 1998, p.36)

According to the table 2.1, it is again evidenced that the diverse characteristics of project team can become a root cause of disputes among the team members.

Accordingly, based on the literature findings, the main causes of disputes among the construction project team members can be tabulated as in table A.1 of Appendix A. As demonstrated in the table A.1, most of the causes of disputes arise due to diversified nature of project team have been identified repeatedly throughout the literature. Therefore, for the purpose of proceeding with the study, the main causes were extracted by eliminating the repetition. Accordingly, difference in interests, objectives and goals; difference in perspectives and default beliefs; conflicts within relationship among parties; influence from social and cultural factors; lack of team spirit; task interdependency; communication gap and information processing methods; competitive/ adversarial attitude by the participants; personal traits; cognitions and competence of the people; slowness of decision making process; and negligence and misunderstandings were identified as the main causes of disputes in a construction project team that are resulted by the varied characteristics of team members.

After identification of the main causes of disputes among construction project team members that arise due to team diversity, it becomes important to explore the existing dispute minimization methods used in the construction industry which has been addressed consequently.

2.6 Existing dispute minimization methods

Identification of causes of disputes directs the research towards the need for discovering existing methods followed to minimize disputes generated by team diversity. Dispute minimization should be adhered from inception stage of a construction project (Yates & Epstein, 2006). As per Latham (1994), dispute minimization can be entertained by the replacement of industry dominating adversarial relationships and practices with team working, collaborative working and partnership between the construction project team.

As identified by Bennett and Gadlin (2012), meeting regularly either physically or virtually; establishing a vision and providing goals formed by a central scientific idea; communicating effectively; and encouraging intellectual disagreement are some of the methods which can be used to minimize disputes among team members that resulted by its diversity.

Further, encouragement on working together with mutual agreements where joint effort and mutual assent can be created is the key to minimize disputes within a construction project team (Yates & Epstein, 2006). As discovered by Moore and Dainty (2001), inspiring the project team members to work as a team treating other members equally can help reducing the disputes within the teams. Moreover, team working approach can assist in minimizing disputes that occur due to opportunistic behavior by promoting cooperation and establishing good relations (Gardiner & Simmons, 1998). Additionally, in order to minimize disputes that arise due to behavioral attitudes, levels of trust within the team should be increased (Loosemore, Nguyen, and Denis, 2000).

Further, research findings of Baiden et al. (2006) revealed that communication becomes an essential aspect in efficient team performance where different skill requirements exists. Additionally, ensuring delivery of right information to the appropriate person at the right time becomes essential for dispute minimization. Moreover, alignment of attitudes within project team and encouraging acceptance instead compliance from members to share a common vision with leadership can assist in minimizing team disputes (Baiden et al., 2006). As identified by Mitropolous and Howell (2001), dispute minimization requires establishing effective problem solving mechanisms within a project team.

In his research, Rahim (1983) has discovered that there are five modes of minimizing disputes in a team as problem-solving, smoothing, forcing, and sharing. Further, while engaging qualified personnel in the team can help in knowing, understanding, respecting and trusting each other, appointing persons with work experience influences building solid relationship resulting increasing the effectiveness in negotiating settlements (Vaaland, 2004).

As stated by Rauzana (2016), disputes among team members can be controlled by responding to problems in a timely manner, creating good communication within project teams, creating a clear mechanism, creating management and good supervision.

According to Vaaland (2004), disputes arising due to team diversity can also be minimized by enhancing the understanding of other party's perception, stimulating openness, reducing relational uncertainty, and analyzing problematic issues before escalating the tension. Moreover, open confrontation of differences rather than smoothing those over or forcing decisions can build up a path to reduce disputes among team members (Lawrence & Lorsch, 1967).

The summary of the literature findings on dispute minimization methods can be tabulated as in table B.1 of Appendix B. Based on the summary in table B.1, it becomes obvious that similar to the causes of disputes, the methods of dispute minimization have been identified repeatedly in existing literature. Therefore, for the purpose of proceeding with the study, the main dispute minimization method were extracted from the table B.1 eliminating the repetitions.

Accordingly, encouraging team work; establishing a vision and providing goals formed by a central scientific idea; creating good communication within project teams; engaging qualified and experienced personnel; increasing levels of trust within the team; establishing effective problem solving mechanisms; and encouraging intellectual disagreement were identified as the main methods of minimizing disputes arising due to team diversity that existing in the construction industry.

Further, summarizing the literature findings, the relationship among the causes of disputes among team members that arise due to its diversity and the available methods of dispute minimization can be demonstrated as in figure C.1 of Appendix C.

Accordingly, it becomes obvious that the identified dispute minimization methods become supportive for minimizing disputes that are generated due to several causes. When exploring the dispute minimizing methods, the need of identifying the available techniques to implement such methods in the construction industry becomes vital. Accordingly, the study has focused on the techniques of implementing dispute minimization methods in the subsequent section.

2.7 Techniques to implement dispute minimization methods

The need of inquiring the possible techniques becomes essential when it comes to the question on how to implement the dispute minimization methods within project teams. Therefore, techniques of implementing each identified method of dispute minimization is described in subsequent subsections.

2.7.1 Encouraging team work

According to Tarricone and Luca (2002), team work can be identified as the situation where members work together in a cooperative environment with the intention of accomplishing a common team goal using shared knowledge and skills. Kobolt and Zizak (2007) have revealed that teamwork is the most optimum way of implementing professional tasks which requires different professional or specialized knowledge. These team members should be provided with a cooperative working environment where goals can be achieved over collaboration and social interdependence rather than individualized, competitive goals (Tarricone & Luca, 2002). Further, as identified by D.W. Johnson and Johnson (1999), a positive interdependent team environment can elicit the maximum efficiency of a person who will encourage the other team members to achieve, contribute, and learn. Additionally, as discovered by Knabb (2000), assigning specific responsibilities to each person can promote teamwork among team members.

Tarricone and Luca (2002) have further disclosed that the key for imposing teamwork environment is the inquiring concerns and needs of team members and valuing their contribution. Moreover, according to Hyrkäs, and Appelqvist-Schmidlechner (2003), supervision is one of the best methods of improving team work.

2.7.2 Establishing a vision and proving goals formed by a central scientific idea

Vision and goal are the two main predictors of project team success (Forester, Thorns & Pinto, 2007). As identified by Locke and Latham (2006), goals can be identified as motivational factors which can compel to use and search for relevant knowledge and skills to achieve a task successfully.

There are four main factors that are used to create goals. These include feedback which assists in identifying the people's progress; commitment to the goal which is powered by self-efficacy and enhancing importance of goals; task complexity which determines the acquisition of complex tasks through task knowledge; and situational constraints which depends on the work load allocation (Brown, Jones & Leigh, 2005). Further, according to Yemm (2012), establishing goals involves assigning roles and responsibilities; and demonstrating processes and explaining team work progression to the individuals.

As per Nanus (1996), a vision can be identified as a realistic, credible, attractive future for an organization which comprises prudently expressed statement of targets to be achieved by a team. Facilitating proper communication among project team members becomes an essential aspect when it comes to maintaining a project vision (Duy Nguyen, Ogunlana & Lan, 2004). Further, according to Chai, Hwang and Joo (2017), having a strong leadership can direct a project team to establish and retain a vision which can ultimately assist in achieving the project goal.

2.7.3 Creating good communication within project teams

Communication is the mode where all required information of a project can be clarified and distributed within its team members (Dainty, Moore & Murray, 2007). Townly (1994) has revealed that communication is an approach of exchanging information as well as a mechanism to change team member' attitudes and behaviors which determines the success of a project. As identified by Dainty et al. (2007), it is challenging to maintain effective communication within project-based environments in the construction industry as interaction are required to be made by unfamiliar groups of people who gather for short periods. According to Cockburn (2000), efficiency of communication depends on the strength of personal contacts.

Moreover, communication and adequate information sharing among team members is one of the major factors affecting project success (Duy Nguyen et al., 2004). In his research, Clarke (1999) has discovered that meetings become compulsory when it comes to creating communication among project team members.

Further, effective communication can be created by establishing communication networks that considers the nature of power relationships. Moreover, leadership within the project team also become a positive drive for effective communication among the team members (Clarke, 1999). Additionally, as identified by Townly (1994), effective communication can be expected where there is adequate training, developing and support for people to improve their communication.

2.7.4 Engaging qualified and experienced personnel

Creating a team with people having required qualifications and experience can lead to project success. Further, suitable arrangement of team members ensures the awareness of their specific role and understanding of their contribution (Tarricone & Luca, 2002). According to Markaki, Sakas and Chadjipantelis (2012), selecting members in a project team requires thorough consideration on knowledge and experience of a person. Tarricone and Luca (2002) have identified that interpersonal skills comprise the capability of open discussions, honesty, trustworthiness, supportiveness, respect and commitment. In their research, Schuler and Funke (1989) identified interviews as one of the common methods used to select suitable team members with required experience and qualifications. However, effectiveness of this approach depends on the style of conducting the interview.

As revealed by Wood and Payne (1998), situational approach, behavioral approach or multi modal approach are some of the effective methods to follow when using interviews to select suitable members in a project team. As identified by Cooper, Robertson and Tinline (2003), selecting members using group discussions regarding the way of candidate's interaction with others; way of expressing himself; and the effectiveness of using his experience can lead to engaging an appropriate members to a team. This method of candidate selection can be identified as the group decision approach (Singh & Tiong, 2005).

In addition, Robertson, Gratton and Sharpley (1987) have identified that psychometric tests which allow to evaluate cognitive ability as well as personality measures can assist in finding the most qualified person who possesses the required personality, skills and competencies.

When construction industry is particularly considered, Hatush and Skitmore (1998) revealed that team members such as contractors should be selected based on their technical experience; organizational structure; financial stability; past performance; and safety records. Topcu (2004) identified this selection method as using multi-criteria decision aid methods.

2.7.5 Increasing levels of trust within the team

As identified by Shockley-Zalaback (2000), trust is the key factor which promotes the effective co-operative behaviors among team members. According to D. Reina, Reina and Hudnut (2017), trust building among project team members should be implemented as a function of managing the project. Propensity to trust, perceived trustworthiness, cooperative behaviors, monitoring behaviors, perceived task performance, team satisfaction, attitudinal commitment and continuance commitment are the main components of trust (Costa, 2003).

According to the findings by Maurer (2010), individual factors such as the amicability of partners; contextual factors such as contractual agreements; relational factors such as mutual interests, shared vision and ideas of collaborative sharing; and organizational factors such as care for team members can be identified as the factors influencing trust among project team members.

Further, research findings revealed that "how employees are managed has a potentially strong influence on the types of social relations they establish and maintain" (Kang, Morris, & Snell, 2007, p.245). According to Inkpen and Tsang (2005), team composition can inspire the development of mutual trust. Additionally, as identified by Holton (2001), frequent and meaningful interactions becomes the basis for developing trust among the members of a project team.

2.7.6 Establishing effective problem solving mechanisms

According to Hyrkäs, and Appelqvist-Schmidlechner (2003), teams confront issues related to control, hierarchy, authority and relationships among team members. In their research, D. W. Johnson and Johnson (1991) identified proper management of resources, network creation, corporative trainings and team building are the main strategies that can be used to resolve problems within a project team. According to Tarricone and Luca (2002), problem solving can be effectively conducted when there is an effective leadership within a project team. Hung (2013) had identified that problem solving is more effective when it is done by a team who can provide collective cognitive components. According to the research findings of Sheremata (2000), new knowledge, new information, and creative ideas which comes in a commencement of a project can initiate problem solving in project teams. As per Llpis (2013), establishing transparent communication, implementing a solid foundational strategy can become beneficial for effective problem solving within a team.

2.7.7 Encouraging intellectual disagreement

As revealed by Owens (2017), intellectual disagreement which promotes participation in decision making; team collaboration, reducing anxiety; and creative thinking, can be advantageous for the success of a team. According to Sikes, Gulbro and Shonesy (2010), effective communication and exploring the reasons for disagreement within team members is the key to be used for encouraging intellectual disagreement. Further, understanding personalities of other team members; gathering data on the view point and providing provisions for questioning are some of the techniques that can be followed to rationally resolve disputes among team members. As identified by Collins (2018), encouraging listening; sharing viewpoints and guiding to seek common grounds can lead to intellectual disagreements.

Accordingly, summary of the techniques that can be used for minimizing disputes among team members of construction project can be illustrated as in the table D.1 of Appendix D.

Based on the findings from the literature survey, fundamentals for developing the conceptual framework to address the research aim can be extracted as described in the subsequent section.

2.8 Fundamentals for conceptual framework of the study

Fundamentals required to develop a conceptual framework of the study were identified based on the thorough literature review carried out using available research materials. The literature findings including causes, minimization methods and minimization techniques of disputes among construction project team members arising due to team diversity were plotted in to the conceptual framework which leads to resolving the research question. Accordingly, the initial phase of the conceptual framework where the basis has been established to achieve the research aim can be illustrated as in figure 2.4.

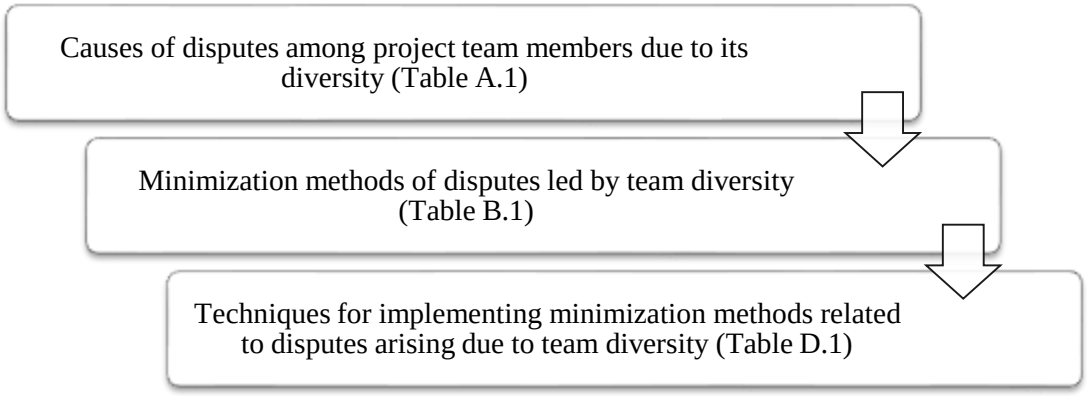

Figure 2.4: Fundamentals for conceptual framework of the study

As demonstrated in figure 2.4, formation of conceptual framework can be initiated by identifying causes, minimization methods and minimization techniques of disputes among construction project team members that arise due to its diversity.

With the intention of achieving the research aim, the conceptual framework was further developed as in Chapter 4 by mapping the BIM features that encourage techniques to minimize disputes among team members of a construction project that arise due to the diversified nature of the team. Accordingly, in order to get a better understanding of further steps of the study, an overview of BIM technology is revealed in next section.

2.9 BIM technology

In order to proceed with the study by mapping BIM features in the developed conceptual framework, obtaining an overall understanding of the BIM technology becomes essential. Building Information Modeling (BIM) is a new IT tool with many benefits that drive the construction industry towards efficiencies by implementing new processes based collaboration between stakeholders (Zuppa, Issa & Suermann, 2009). According to Chen and Luo (2014), BIM is identified as a tool that assists for visualizing and coordinating AEC (architecture, engineering and construction). Further, Kymmell (2007) classifies BIM as a tool, process or a product which can build up virtual intelligent models with connections to construction management tools encouraging teamwork, visualization and constructability.

According to The Landscape Institute (TLI, 2016) and; Gu and London (2010), based on the level of adoption within a practice, there are 4 levels in BIM as level 0, level 1, level 2 and level 3 where the differences can be tabulated as in table 2.2. According to the table 2.2, it becomes obvious that among the other levels, BIM level 3 is the highest level available in the industry which has not yet been achieved up to date.

Table 2.2: Different levels of BIM implementation

BIM level	Used technology	Description
0	Unmanaged Computer Aided Design (CAD) in 2D	Printed or digital un-editable documents are used for information sharing
1	Modelling- Managed CAD in 2D or 3D	A cloud based collaboration tool which acts as the Common Data Environment (CDE) is used for information sharing. Commercial data is managed separately without integration
2	Collaboration- Managed 3D environment	Combined file formats and software tools are used for information sharing. Time planning and cost planning features are integrated within the system
3	Integration- Managed 4D (construction sequencing), 5D (cost) and 6D (project lifecycle information) environment	Known as the next level of BIM. Integrated electronic information with full automated connectivity and web-stored is used for information sharing. Not practically achieved yet.

Further, as reveled by Ganah and John (2014), at the current context, the ultimate goal of the construction industry practitioners as well as the stakeholders should be to achieve an integrated platform to collaborate which facilitates an effective and efficient working environment. Additionally, Ganah and John (2014) stated that BIM level 2 has become capable of delivering this competence to the construction industry.

Moreover, a similar representation was provided by Eynon (2016) referring to the BIM maturity levels as described in 'Bew-Richard's maturity ramp'. 'Bew-Richard's maturity ramp' which is illustrated in figure 2.5 describes the integrity of BIM under each BIM level.

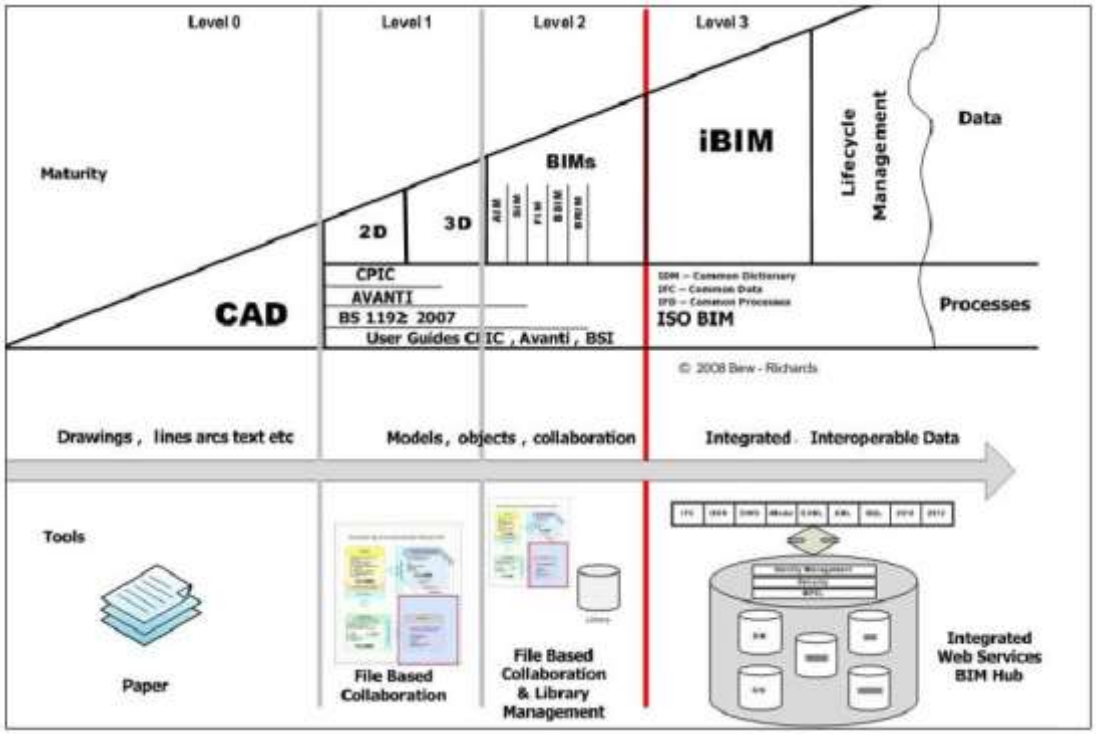

Figure 2.5: Bew-Richards maturity ramp
Source: (Eynon, 2016)

Accordingly, with the intension of establishing scope limitations for the study, BIM level 2 is identified as the BIM technology considered hereafter for the purpose of this study.

As identified by Alshawi, Goulding, Khosrowshahi, Lou, and Underwood (2008), even though the benefits of BIM technology can be well understood, people are reluctant to adhered to this new technology due to various reasons. Further, according to Chien, Wu and Huang (2014), BIM implementation in construction industry requires confronting many challenges and risks. These challenges can be observed in terms of teamwork, collaboration, and information sharing (Bryde, Broquetas and Volm, 2013). As identified by Yan and Demian (2008), most organizations in the construction industry are reluctant to use BIM technology due to the challenges it involves. Therefore, it is evidenced that BIM is a new technology with numerous benefits for the construction industry which requires higher motivation for implementation.

Accordingly, it becomes obvious that certain BIM features imitate the dispute minimization techniques discovered through the literature review of the study. Therefore, it is noticeable that there is a potential of BIM technology to have features which can enhance the dispute minimization within a project team.

2.10 Summary

This chapter has looked into the definition of the term ‘dispute’ to avoid misperception that may occur while differentiating the meanings of terminologies, conflicts, claims and disputes. Further, the impact of disputes on construction projects has been recognized in order to emphasize the importance of dispute minimization in the construction industry and to recognize the main sources of disputes that give rise to disputes caused by team diversity. Consequently, the existing methods of minimizing disputes arising due to diversified nature of team members and the techniques available for implementing such minimization methods have been identified as a basis for developing the conceptual framework to recognize BIM features that can enhance existing dispute minimizing techniques. The next chapter describes the research methodology of this study.

CHAPTER 03

RESEARCH METHODOLOGY

CHAPTER 3
RESEARCH METHODOLOGY

3.1 Introduction

This chapter mainly emphases on setting out the methodological framework that guides this research to attain its aim and objectives. The research methodology adopted under each section of the study in accordance with the research design is demonstrated in this chapter.

3.2 Research Process

The experience gained as a professional QS (Quantity Surveyor) in addition to being a team member of building construction projects and the theoretical knowledge obtained on BIM technology through the Master of Science degree programme on Construction law and Dispute Resolution has provided the initial intensive of carrying out this study. Establishing the research topic was done by going through relevant research materials followed by the guidance of research supervisor. The research process of this study is given consideration in terms of background study, literature review, research problem statement, choice of research design and manner of designing which are described in the subsequent subsections as illustrated in figure 3.1.

As demonstrated in figure 3.1, the research aim including the research objectives were established after identification of the research problem. Further, a thorough literature review was conducted to affirm the basis of research aim as well as to form the fundamentals for developing the conceptual framework for the study. Collection of primary data was conducted through a qualitative observational study using an internet mediated method where online sources were referred to collect information. Subsequent to analyzing the collected data from qualitative observational study, the findings were mapped to complete the conceptual framework for the study. The completed framework was validated by the BIM experts in the field and followed by the conclusion and recommendations.

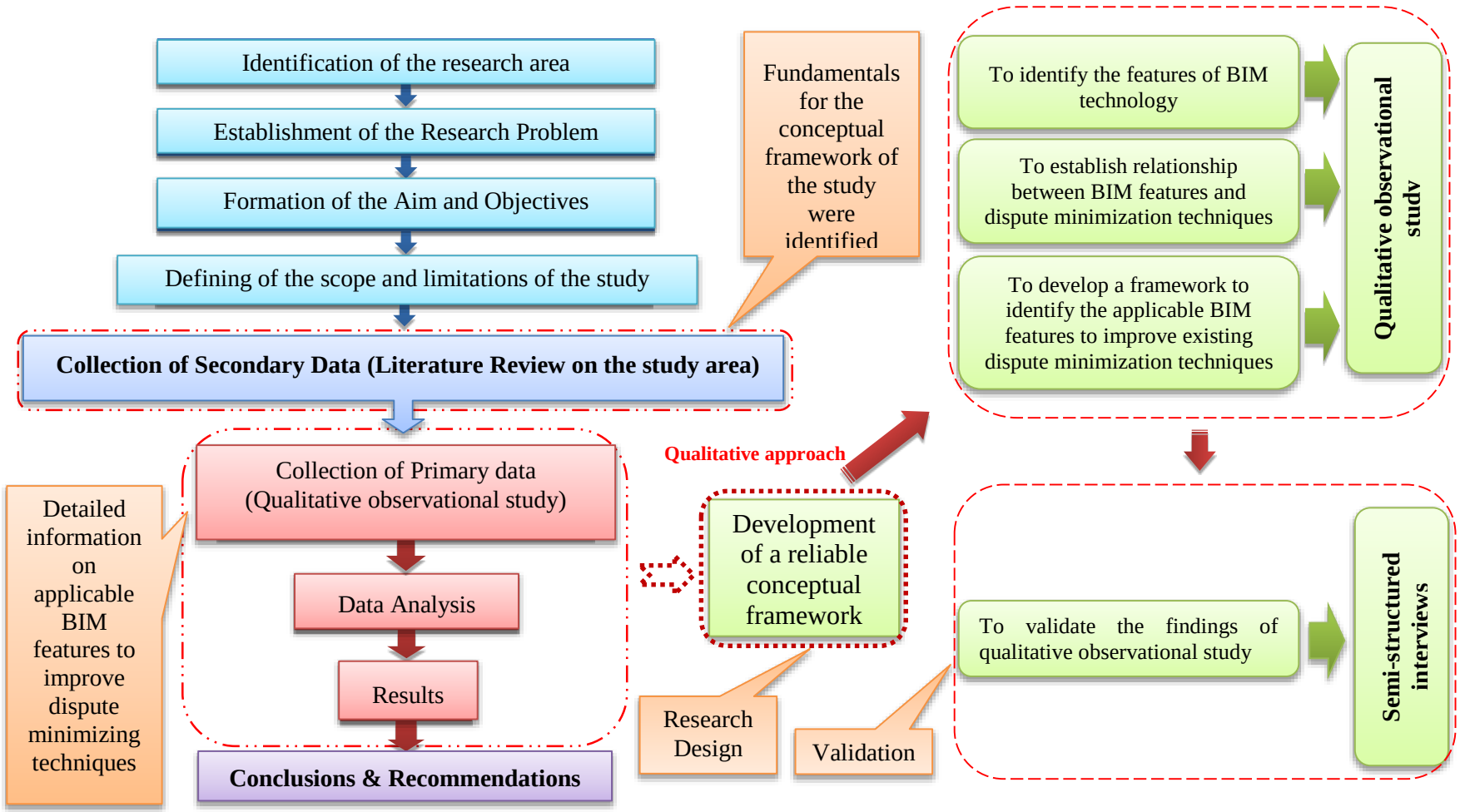

Figure 3.1: Selected research approach for the study

3.2.1 Background study

The main focus on the background study of this research was to demonstrate the basis of the subject area. Books, journal articles and other relevant research materials were referred in this stage and it was evidenced that there has not been any research carried out to establish the applicability of BIM technology as an encouragement to minimize disputes that occur due to the diversity of team members of a construction project. Therefore, an in-depth literature synthesis has been carried out in order to identify the existing knowledge within the construction industry on minimization of disputes arising due to team diversity.

3.2.2 Literature Synthesis

A comprehensive literature review was carried out with the intension of ascertaining the existing knowledge on disputes that arise due to diversified nature of the project team members; available methods for minimizing disputes arising due to team diversity and; the techniques used for implementing such dispute minimization methods in the construction industry. Further, significance of the BIM technology was explored as a basis of materializing the research problem. The information was mainly collected through books, journal articles and research papers that were already published under the subject area. Findings of the literature synthesis were then used to initiate the development of a conceptual framework to establish the research problem.

3.2.3 Research Problem

As revealed by the literature synthesis, no literature is available with a direct discourse regarding the relationship between dispute minimization mechanisms and features of BIM technology. Research problem was developed based on the knowledge gap identified through the literature synthesis related to the connection between dispute minimization in the construction industry and BIM technology. Accordingly, the research problem was defined as ‘can BIM technology be applied to improve dispute minimization among project team members that arise due to their diversity’. In response to the recognized research problem, the research design was established to carry out the study.

3.2.4 Research Design

Research nature becomes the basis for selecting the method of carrying out a research (Noor, 2008). As identified by Punch (2005), the research design acts as the connector between research question and data. As per the elaborated research problem, a detailed analysis of the BIM features in respect to the existing dispute minimization techniques becomes essential in order to determine the applicability of BIM technology for improving minimization of disputes within a project team that arise due to team diversity.

Therefore, a validated conceptual framework has been established to achieve the research aim by firstly identifying the fundamentals for the conceptual framework from literature findings on causes and available methods of minimizing disputes among team members that are generated due to team diversity; and the techniques available in the construction industry to implement the identified dispute minimizing methods.

3.2.5 Research Approach

A researcher confronts two research approaches as quantitative and qualitative (Kraemer, 2002). As revealed by Yin (2003), a qualitative research becomes more effective when there is an interest of investigating detailed and in-depth information. As the research aim is focused on identifying the applicability of BIM technology in minimizing disputes among construction project team members that arise due to team diversity, fundamental attention of the research was given to explore the basis and techniques of minimizing such disputes. Therefore, the research aim is more in the direction of qualitative data where the quantitative data will not be providing a rational and proper contextual approach to reach the outcome of the research. Hence, based on the nature of the study and available background evidences, the qualitative approach was selected as the most suitable research approach. Subsequent to selecting the research approach, necessity of identifying the research technique arise as explained in the next section.

3.3 Research Technique

Adopted research technique can be more elaborated as data collection and data analysis which is presented in the subsequent subsections.

3.3.1 Data collection

According to Gill, Stewart, Treasure and Chadwick (2008), there are various techniques of data collection under qualitative approach including observations, textual or visual analysis and interviews. Therefore, it is obvious that the most appropriate method for the research which can derive the study towards its aim through achieving the established objectives should be selected from these available methods.

Accordingly, with reference to the research aim identified in section 1.3, it can be determined that the research is intended to examine the applicability of BIM technology for improving techniques for minimizing disputes within construction project team members that arise due to team diversity. In their research, Bakis, Kagioglou and Aouad (2006) have identified that case study approach is the best suited data collection method for researches concerning information technologies. However, BIM is a technology that is still under development in the research location (Sri Lanka) where it made the performance of a case study for the research purpose beyond the practicable nature. Further, conducting interviews, industry experiments or questionnaires for the data collection were far behind due to both geographical and time limitations.

Therefore, considering the achievability, a qualitative observational study in the form of desk research using online sources was selected as the most appropriate method for data collection where information was gathered through research publications, online forums, websites, personal and company blogs, online discussions at professional networks, online newspapers, online magazines, BIM guidelines and BIM policies. Selection of qualitative observational study for the study is further justified subsequently.

Qualitative observational study using online sources

As identified by Kumar (2008), when considering observation as a data collection method, it involves collecting information by a way of investigating own observations without conducting interviews. When a research is focused on a technological aspect, an observational study can become comparatively effective (Saunders, Lewis & Thornhill, 2016).

Moreover, as observation can create a better understanding of a particular subject, the intention of a person regarding the subject matter can be extracted without observer's participation. Therefore, this technique can become more effective when used as a non-participatory method which can be identified as a less time consuming data collection technique.

Further, as identified by Im and Chee (2012) and Bíró, Botzenhardt and Ferdinand (2014), qualitative observational studies can be carried out using an internet mediated data collection method where online resources are mainly referred for information gathering. Therefore, this study has used a technique which can be identified as a deviation from the traditional observational study. Accordingly, under this method, observations have been made on opinions from the online sources in the place of traditional extreme observations. The data collection is carried out using sources such as research publications, online forums, websites, personal and company blogs, online discussions at professional networks, online newspapers, online magazines, BIM guidelines and BIM policies which are elaborated in the subsequent chapter.

Moreover, based on the feasibility of the research study and considering the geographical and time constraints, the collected opinions through online sources were identified as reliable and accurate. Additionally, it is assumed that the statements made by each person regarding the subject matter has replicated his/her true and own views and judgments. Following the data collection, the next stage of the study was to analyze the collected data to drive the research towards its aim.

3.3.2 Data analysis

The purpose of analyzing the gathered data was to understand the basis for disputes occurrence and the requirements for minimizing such disputes that arise among team members of a construction project team due to team diversity. After collecting the data as demonstrated in subsection 3.3.1, key dispute minimization techniques were identified as codes in order to proceed with the analysis. As revealed by Westbrook (1994), content analysis is the most reliable mechanism to analyze qualitative data among the various techniques available for data analysis as it provides logical and reliable implications of the collected data.

Further, content analysis uses codified qualitative information which are predefined in to categories making it useful in reporting information while conducting the analysis (Guthrie, Petty, Yongvanic & Ricceri, 2004). The analysis was further supported by the NVivo software (Version 12) which assisted in categorizing research findings. Moreover, as revealed by Hsieh and Shannon (2005), content analysis technique can be applied for the text data which can absorb, summarize and define the content included. Therefore, for the purpose of analyzing and summarizing the collected data from the study, code-based content analysis has been selected.

As the subsequent step of the study, a conceptual framework was developed based on the findings from the data analysis. Further, this framework was validated with the input from industry experts with the purpose of enhancing the reliability of research outcome. The procedure used for validation of the conceptual framework is elaborated in the subsequent section.

3.4 Validation of the conceptual framework

The development of conceptual framework subsequent to data analysis directed the study towards validation of the research outcome. As identified by Saunders et al. (2016), the validity of the collected data from the qualitative observational study can be impacted through biasness depending on the root of the data sources. Therefore, the validation of the collected data for the research analysis becomes vital to maintain the quality and reliability of the study.

However, as revealed by Leavy, Hesse-Biber (2010), validation of data collected from qualitative observational study is restricted to a certain level by the technique itself. Therefore, in order to validate the conceptual framework that was developed through the research findings and analysis, opinions of the BIM experts in the field were examined. As stated by Sekaran (2003), face-to-face mannered interviews facilitates the researcher to capture the nonverbal traces from the respondent. Therefore, face-to-face semi-structured interviews were conducted with BIM experts in construction industry to extract their opinions on the validity of the research findings and suggestions on improvements on the developed conceptual framework through the study.

3.4.1 Semi-structured interviews

The semi-structured interviews were started by selecting the interviewees and forming an interview guideline.

Selecting the interviewees

As the intention of the semi-structured interviews was to validate findings of the study where a conceptual framework was developed to identify the techniques for minimizing disputes arising due to team diversity that can be implemented through the revealed BIM features, the experts with firm knowledge on BIM technology as well as construction industry had been selected. As revealed by Ismail, Chiozzi, and Drogemuller (2017), BIM technology has not yet been accepted in the Sri Lankan construction industry where the research is being carried out. Therefore, the resources availability in terms of interviewees suitable for the study had been limited. Hence, five (5) BIM experts were selected considering their experience in the construction field and the expertise on BIM technological knowledge. Moreover, the geographical constraints and time constraints were also taken in to account while selecting the interviewees. Accordingly, the general information of the interviewees can be tabulated as in table 3.1.

Table 3.1 General information of interviewees

Interviewee reference	Current designation	Experience in the construction industry	Experience with BIM	Experience in witnessing team disputes
EX1	Senior Architect/ Project Coordinator	11 years	8 years	Yes
EX2	Senior Project Architect/ BIM Manager	18 years	10 years	Yes
EX3	Head of the Quantity Surveying Department (Academic)	19 years	9 years	Yes
EX4	Contracts Manager	13 years	3 years	Yes
EX5	BIM Coordinator	6 years	5 years	Yes

Interview guideline

Interview questions were mainly based on the intention to validate the conceptual framework developed for the study. Therefore, other than confirming the BIM expertise of the interviewee through inquiring general information relevant to their professional experience, the interview was mainly focused on obtaining the expert opinions on the validity of the research findings. Structure of the interview guideline can be tabulated as in table 3.2 where reference is given to the literature findings elaborated in subsections of Chapter 2.

Table 3.2: Structure of the interview guidelines

Literature findings	Reference to Chapter 2
Encouraging team work	2.7.1
Establishing a vision and providing goals formed by a central scientific idea	2.7.2
Creating good communication within project teams	2.7.3
Increasing levels of trust within the team	2.7.5
Establishing effective problem solving mechanisms	2.7.6
Encouraging intellectual disagreement	2.7.7

Interview process

The interviews were carried out with BIM experts from the construction industry in face-to-face manner using semi-structured interview method adhering to the guideline referred in Appendix E. Further, conversations of the interviews were tape-recorded with the permission of interviewees to develop accurate interview transcripts (see Appendix F for an example of interview transcript). In this research, 5 interviews were performed which normally lasted for 45 minutes.

After carrying out the data collection, analysis and validation of the developed conceptual framework of the study, the next step of the research was to write-up, which is described in the subsequent section.

3.5 Write-up

Write-up of the research was started gradually with the commencement of the analysis of the collected data which ultimately directs the study towards its conclusion and recommendations.

3.6 Validity and reliability of the research

Validity and reliability are two most important factors that comes in to action when designing a study, analyzing results and judging the quality of the study (Golafshani, 2003). There are four tests as construct validity, internal validity, external validity and reliability that can be followed to evaluate a qualitative research (Yin, 2003). Table 3.3 describes the evaluation of the study in terms of the above identified tests.

Additionally, table 3.3 reveals that the study has effectively focused on achieving construct validity, internal validity, external validity and reliability through the established research methodology. Accordingly, it can be identified that the research has successfully achieved its validity and reliability which has ultimately resulted a consistent research outcome.

Table 3.3: Validity and reliability of the research

Test	Description	Procure in the research
Construct validity	Establishment of unexceptionable operational measures for the concepts being considered	*Applying multiple data collection and analysis methods*: The multiple data collection includes literature synthesis and qualitative observational study. Semi-structured face to face interviews were carried out to validate the research findings. Different kind of literature, qualitative data analysis was done through content analysis.
		Selection of data sources for observational study: The selection of sources had been done based on the reputation in relation to the BIM industry
Internal validity	Establishment of casual correlations, whereby certain conditions are shown to lead the other conditions, as distinguishes from credible relationships	*Linking data to the framework*: Establishing an analytical framework while conducting the study
		Logical analytical process: Cross reference was made to the literature findings while conducting the analysis
External validity	Establishment of a domain to which study's findings can be generalized	*Sources of data collection for observational study:* Data collection for observational study was carried out using different types of sources including research publications, online forums, websites, personal and company blogs, online discussions at professional networks, online newspapers, online magazines, BIM guidelines and BIM policies
Reliability	The demonstration of the operations of a study	*Clearly defined research methodology*: Following logical sequence of steps

3.7 Summary

This chapter was mainly focused on emphasizing the research design including data collection method and data analysis procedure. Accordingly, a qualitative design approach was selected for the study where the data collection was decided to be carried out using a qualitative observational study referring online resources. The method of data analysis was selected as content analysis and the retrieved information was decided to be mapped in the conceptual framework of the study which was developed using the literature findings. This significant framework that directs the study towards its aim was then decided to be validated using expert opinions to enhance the validity and credibility of the research findings.

The method of collecting the expert opinions was selected as the semi-structured interviews with selected BIM specialists in the construction industry and the gathered perceptions were decided to be considered to draw conclusions and recommendations of the study. Additionally, further steps that were taken to ensure the validity and reliability of the research findings were described at the end of this chapter.

CHAPTER 04

RESEARCH FINDINGS AND ANALYSIS

CHAPTER 4

RESEARCH FINDINGS AND ANALYSIS

4.1 Introduction

The research methodology of the study has been elaborated in chapter three and chapter four focuses on an in-depth analysis of the research findings that derived from the fundamentals of conceptual framework in section 2.8. This chapter begins with a detailed explanation of the sources used for data collection which include research publications, online forums, online discussions at professional networks, personal and company blogs, websites, online newspapers, online magazines, and BIM guidelines. Subsequently, it provides a comprehensive analysis of the available techniques to minimize disputes among project team members in relation to the BIM technology which completes the development of conceptual framework to resolve the research problem. Finally, the chapter concludes by providing the finalized conceptual framework which summarizes the research findings that lead to answering the research problem.

4.2 Data sources used for data collection

As discovered through the literature review, construction industry of the study location, Sri Lanka, is identified as novel to the BIM technology. As a result of this constraint, data collection for the study was limited to the opinions extracted from online sources as referred in subsection 3.3.1. Accordingly, due to the limited availability, the data sources were selected without firm boundaries. The detailed list of data sources can be identified in Appendix G.

The data included various opinions related to the study matter with sufficient background to the required information. As per the identified nature of the study, the research requires identification and validation instead of criticism over the research findings. Thus, any material with indication of minimizing disputes arising from team diversity using BIM technology were considered as adequately fulfilling the requirement of the observer.

Additionally, the collected research data were mainly based and agreed on a common view point where no criticism involved over other opinions. Further, reliability of data sources used for the analysis has been considered accordingly. Different types of online data sources used for the research has been elaborated in detail throughout the subsequent subsections.

4.2.1 Websites

For the purpose of carrying out the study, only the websites which cannot be edited by the user have been selected for collecting data. In general context, even the author(s) of the website had been interviewed despite the geographical constraints, the content of the website and the author's opinions are unlikely to have drastic variances. Therefore, it becomes obvious that the data collected through websites can be reliable in terms of the opinions by the author(s).

4.2.2 Online newspapers and magazines

Newspapers and magazines that are published online have more attraction of the readers due to its convenient availability. The desirability extends towards the professionals who are knowledgeable and interested in getting updated regarding the subject matter. As a result, the editors tends to ensure the reliability and accuracy of their publications.

4.2.3 Personal and company blogs

Blogs by persons and companies are created by responsible parties who ensure the reliability of their opinions and viewpoints. These thoughts are shared word wide and as readers with knowledge and experience on the subject matter become users of these blogs, the authors tend to maintain a considerable accuracy on their output.

4.2.4 Online discussions at professional networks

Discussions carried out in professional networks are mainly based on online or offline platforms where professionals with knowledge and experience who have similar interests are gathered.

Unlike in social media network services where personal relationships are maintained, these links are created among industry specialists who are focused on business nature interactions. Therefore, the information shared in these networks have a considerable reliability due to the fact that the opinions are delivered by professionals who would have the same viewpoints even though they are inquired through an interview.

4.2.5 Online forums

Online forums are referred to the platforms where knowledge, ideas and viewpoints in relation to a particular subject matter is discussed and shared. This is a knowledge enhancing process where personnel with similar interests are grouped to share their ideas.

4.2.6 Research publications

Publications by the researchers who have thoroughly investigated a subject matter were used for data collection. This source was identified more reliable compared to the other sources used for the study.

4.2.7 BIM guidelines and protocols

BIM guidelines and protocols assist in maintaining a proper sequence when adhering to BIM technology in to a construction project. Further, they provide adequate information of the role of the team members which reveal the details on team diversity. Since these guidelines and protocols are practically being used in the industry, there is a considerable reliability and accuracy that can be adopted while collecting data through this source.

When considering the sources referred in subsection 4.2.1 to 4.2.7, it becomes obvious that the opinions and viewpoints of the author(s) are unlikely to change depending on the means of collecting information. Therefore, it can be argued that the reliability and accuracy of the available information mainly depend on the fact that there would be no difference in opinion from the authors even an interview is held disregarding the geographical constraints. Accordingly, using the sources referred above, the data collection for the study has been carried out.

Further, as the next step of the study, the collected data were analyzed with assistance of the NVivo (Version 12) software as demonstrated in the subsequent section.

4.3 Data analysis

Subsequent to conducting data collection with the use of data sources described in section 4.2, the data analysis was carried out for completing the conceptual framework of the study. For the purpose of easy reference, the selected data sources were codified as in Appendix G. Collected data were then categorized according to the dispute minimization methods which were identified in section 2.6 of the literature review chapter. These categories included encouraging team work; establishing a vision and providing goals formed by a central scientific idea; creating good communication within project teams; engaging qualified and experienced personnel; increasing levels of trust within the team; establishing effective problem solving mechanisms; and encouraging intellectual disagreement.

Accordingly, the recognized dispute minimization methods were analyzed in-detail in subsequent subsections referring to the features of BIM technology that inspire the identified dispute minimization techniques which were revealed in section 2.7. These main dispute minimization techniques can be illustrated in a coding structure as in figure 4.1.

Figure 4.1: Coding structure for main areas discussed within the study
(Refer Appendix H for the full coding structure)

4.3.1 BIM features for encouraging team work

As revealed by the literature review, encouraging the team work can be resulted by assigning specific responsibilities to the team members; inquiring concerns and needs of team members; providing cooperative working environments; providing positive interdependent team environment; providing adequate supervision; and valuing team members' contribution. The coding structure related to the BIM features for encouraging team work can be illustrated as in figure 4.2.

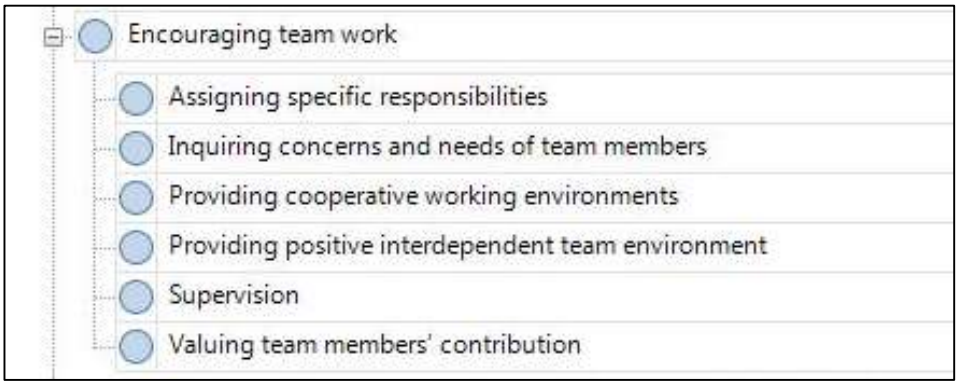

Figure 4.2: Coding structure for techniques for encouraging team work
(Refer Appendix H for the full coding structure)

WS1 stated that in projects where BIM is implemented, specific functional areas are assigned to the team members for carrying out their work. Further, GP1 has discovered specific responsibilities against each team member of a typical project team which includes examples such as *"Design Team BIM manager should assemble composite design model for coordination meetings"* and *"Construction BIM Manager should coordinate construction sequencing and scheduling activities; and assures they are integrated with the construction BIM".* As identified by WS17, "to *collaborate efficiently and effectively among different disciplines and across different organizations, it is essential to have standard methods and procedures and a common data environment with clearly defined roles and responsibilities".* Therefore, it is evidenced that construction project teams which involves members in different disciplines can be benefited by BIM technology as assigning specific responsibilities becomes a feature that can be undeniably expected while implementing BIM technology in a project.

As revealed by RP28, inquiring concerns and needs of team members can be more efficiently done by personal interactions with team members, particularly by the team leader. However, as identified by WS18, BIM technology can facilitate managing the project team through online platforms such as *"Auto desk, BIM 360 team"* which decreases the individual interferences among the team members. Accordingly, it becomes obvious that available data does not provide sufficient evidence on the ability of BIM technology to facilitate inquiring concerns and needs of team members to encourage team work.

As stated by WS1, "*BIM allows multiple team members to work on the same project model at the same time"*. Further, as per WS2, ONM6 and RP1, BIM promotes collaboration among project members providing a cooperative working environment. Moreover, ONM6 stated that *"in this environment, all stakeholders in the construction process including owner/developer, project managers, consultants, contractors, sub-contractors and facilities management, have access to the same design, cost and scheduling information at the same time"*. Therefore, it becomes obvious that the common platform provided by BIM technology for simultaneous working of team members facilitates an extensive corporative working environment to the team members.

While identifying positive interdependence, RP27 stated that *"in a collaborative setting, the success of one person is dependent on the success of the group; this is referred to as positive interdependence".* According to WS1, *"when using BIM technology, project elements or systems are separated into individually managed models that can be linked together".* Further, as revealed by WS1, these models enable work sharing among team members. As disclosed by RP4, BIM implementation within a project team generates a network and an interdependent environment. Hence, it shows that an enhanced positive interdependent team environment can be expected by implementing BIM technology in a project which provides a collaborative setting.

RP7 stated that *"BIM models with attributive information can support the information sharing and collaborative work among the involved users, which makes it possible to improve the quality supervision".* Above statement exposes that BIM implementation facilitates work supervision within a project team. Further, according to WS4, since BIM provides access to the planned works of each team member, the supervision of actual implementation can become more productive and convenient. Accordingly, it becomes obvious that BIM which facilitates information sharing and collaborative work environment assists in providing supervision of team members which ultimately promotes team work.

ONM7 identified BIM as a *"data aggregation platform"* which allows the users to access required information with comfort. This BIM feature ensures the team members to have access for the information to proceed with their functions. According to RP6, BIM can enhance the *"productivity and value across many stakeholder groups".* As revealed by RP22, due to the easy access to work relevant information, BIM assists in increasing the efficiency of team members which elevates the value of their contribution towards the team. Therefore, it demonstrates that the chance of a team member to get appreciated grows due to BIM usage. However, the findings do not reveal the significance of BIM as a sponsor to motivate valuing team members' contribution. Therefore, it can be identified that BIM support on member appreciation is limited to a given extent.

4.3.2 BIM assistance in establishing a vision and providing goals formed by a central scientific idea

According to the literature findings, establishing a vision within a project team and setting goals towards a central specific idea can be achieved by providing feedback, ensuring commitment to the goal, task complexity; situational constraints; assigning roles and responsibilities; demonstrating processes; explaining team work progression to the individuals; facilitating proper communication among project team members; and strong leadership. These techniques can be demonstrated using the code structure as in figure 4.3.

Figure 4.3: Coding structure for techniques for establishing a vision and providing goals formed by a central scientific idea (Refer Appendix H for the full coding structure)

Further to the identification in subsection 4.2.1, RP2 declares that BIM can facilitate assigning roles and responsibilities of team members by identifying it as a pre-requisite for implementing BIM in a project. Accordingly, it becomes obvious that using BIM can provide a substantial foundation to assign relevant roles and responsibilities to the members of a project team.

WS6 stated that *"When BIM is used, everyone involved with the project can have a clear goal to work towards"* stressing the support of BIM technology for ensuring commitment of team members to achieve specific goals. However, the available data does not reveal the significance of BIM technology in directing the team members towards the project goal compared to an ordinary project.

With their statement *"the organization should be explicit about their target market and the size, type, and approximate duration of the project it is developing in order to timely inform requirements and provisions for respective contractors in alignment with BIM deliverables"*, RP3 evidences that successful BIM implementation requires proper demonstration of the processes involved in the project. Accordingly, it can be recognized that BIM implementation which requires establishing the manner of conduct of the project as a pre-requisite enhances demonstrating processes within the project.

Research findings of RP9 revealed that *"the visualization from BIM 3D/4D model helps engineers or planners to become more confident about real happenings on the construction site".* Further, as discovered by RP10, in order to get this benefit, BIM model should be created against the project planning activities. Therefore, it becomes obvious that BIM feature which allows to simulate the actual events of the project can improve the ability of explaining the team work progression to the individuals to establish goals within the project.

PCB1 indicated that BIM which provides a visual representation of an entire lifecycle of a building can *"help the project team to stay on the same page and communicate crucial updates on a timely and straightforward manner when necessary".* This statement replicates that BIM becomes a good medium of communication among team members. Therefore, it is evidenced that BIM technology improves the proper communication among project team members which facilities establishing common goals within the project.

As revealed by ONM8, availability of feedback for project team on specific tasks that are carried out by the members is among the various benefits of using BIM technology. RP8 stated that *"by using the BIM technology, project managers and engineers can gain knowledge related to BIM and obtain feedback provided by jobsite engineers for future reference".* Accordingly, it can be identified that BIM is a technology which can improve feedback process on executed work by its ability to simulate the actual progress of the site in a shareable model.

According to ODPN1, *"with BIM, one can predict the timescale involved for the project which can be monitored during actual construction on site. Also, there is more clarity amongst the project team which means no or rather fewer misunderstandings and disagreements".* This statement affirm the applicability of BIM technology in situations where constraints are confronted. However, a supposition cannot be drawn from the existing knowledge to assure the BIM capability to decrease situational challenges.

As per a job advertisement published in OF1, strong leadership is required for implementing BIM in a project to uphold the project goal. Conversely, the available data has failed to establish the importance of BIM technology in achieving improved leadership in comparison to the project with traditional practice. Therefore, it can be identified that though BIM promotes possessing strong leadership, it does not inevitably provide leadership within the project.

PCB4 and RP5 discovered that BIM allows complex work items in to be divided in to manageable tasks which makes setting out goals more convenient. Therefore, it can be identified that task complexity can be well managed by using BIM in a project. However, the particular features of BIM which facilitates the acquisition of complex tasks through task knowledge has not been revealed within the construction industry. Accordingly, it can be recognized that BIM facilitates establishing goals within a project without adequate significance compared to projects without BIM adherence.

4.3.3 BIM for creating good communication within project teams

As identified through the literate review, increasing strength of personal contacts; holding meetings; establishing communication networks; providing leadership; providing training, developing and support for improving communication are the main techniques of creating good communication within project teams. Techniques of creating good communication within project teams that were used for the data collection and analysis can be shown as in figure 4.4.

Figure 4.4: Coding structure for techniques for creating good communication within project teams (Refer Appendix H for the full coding structure)

When it comes to establishing communication networks through BIM technology, PCB1 stated that *"for the professionals (architects, surveyors, engineers) involved in an infrastructure project, BIM allows for a virtual information model to be communicated from the design team to the main contractor and subcontractors and then to the owner/operator with each specific professional adding specific data to the single-shared model".* This affirms that BIM has made information sharing very convenient where other team members can access the required details without complications. Further, according to PCB1, this system reduces information losses in circumstances such as when taking over a project by a new team. Moreover, introducing an innovative feature of BIM, ONM1 stated that *"the new solution, which will be fully integrated with LetsBuild's APROPLAN app, is designed to put BIM into the hands of construction workers, allowing them to provide real-time data from site without having to struggle with unfamiliar tools".* The ability of exchanging a virtual information model with real time data among the team members assures that BIM technology can drive a project team to establish a better communication network.

As identified by PCB1, BIM reduces coordination time and effort on manual checking of team work due to its in-built flexibility on exploration and changing to project design or documentation process. Therefore, it is evidenced that the requirement of holding meeting in a BIM implemented project is comparatively minimized. This has been further admitted by OF2 which stated that *"now collaboration is more intense in various phases and it takes a lot of organizing so that people are not sitting unnecessarily in meetings".* However, according to ONM9, it is essential to have meetings among team members in order to achieve the maximum advantage of implementing BIM. Since the available information does not establish a firm indication on the BIM assistance in improving conducting of meetings, it can be stated that implementing BIM can encourage holding meetings to a given extent.

As identified by PCB2, BIM facilitates team members to exchange information using technologies such as 'cloud' which provides a convenient mode of access to data. Therefore, it becomes obvious that BIM compel team members to adhere to using technology rather than traditional personal contacts.

Accordingly, it can be identified that BIM does not promote in increasing the strength of personal contacts. This has been further affirmed by RP11 which recognized BIM being superior in documentation work compared to all other communication modes.

Similar to the facts discussed in subsection 4.2.2, BIM implementation promotes establishing strong leadership within a project team. Further, according to WS5, the team leader in BIM implemented project is expected to facilitate communication among the team members. Although it is evidenced that BIM can provoke the leadership to simplify exchanging information within the project team, the existing knowledge does not assure the BIM capability in providing extensive leadership toward a project team.

As per the guideline provided by GP2 in relation to the BIM implementation in a project, training programme should be adopted. This has been further elaborated by its statement *"learning can take place in the forms of formal BIM training courses where new skills are acquired; mentoring where more experienced staff are paired up to guide the less experience ones; forum where leaning points are shared or obstacles discussed among practitioners; and good practices where all learning points are documented".* Therefore, it becomes obvious that the essential pre-requisite of training in BIM implementation does not only promote training on BIM technology but also the path towards improving communication among project team members.

4.3.4 Applicability of BIM for engaging qualified and experienced personnel

The literature survey discovered that qualified and experienced personnel can be engaged in to a project team mainly by holding interviews; using group decision approach; using psychometric tests and using multi-criteria decision aid methods. According to the developed code structure, techniques considered under this dispute minimization method can be illustrated as in figure 4.5.

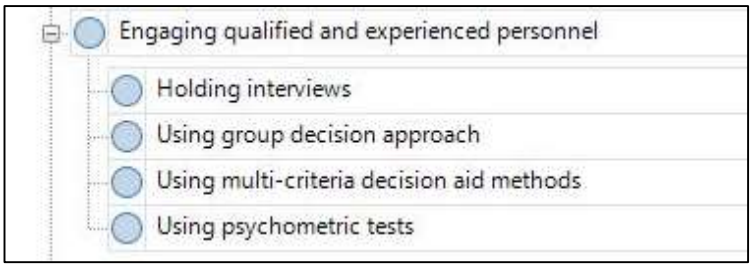

Figure 4.5: Coding structure for techniques for engaging qualified and experienced personnel (Refer Appendix H for the full coding structure)

As identified by ONM2, ideal members for the BIM team should be selected by a properly organized interview. According to RP12, team members in a BIM implemented project should be selected based on their communication skills, personal traits or personality which can only be examined through an interview. This is further confirmed by their statement, *"I hire for personality, never hire for technology. That's skills to be learnt".* Therefore, when selecting candidates for a BIM implemented project, interviews play a considerable role for selecting the most suitable member for the team. However, the available data has been unsuccessful in demonstrating the significance of BIM implementation in improving the requirement of carrying out interviews selecting the most suitable candidate for the project.

RP13 has mentioned that team selection in a BIM implemented project which is done in the project start up should be the team leader's combined effort with the BIM manager. With this finding, it can be identified that BIM implementation in a project promotes using group decision approach while selecting the matching best candidate to perform in the team. Nevertheless, the evidence available in the industry are not adequate to prove that BIM has an influence in enlightening the group decision approach compared to the project without BIM adoption.

According to RP3 who stated *"the selection of professionals that best meet the profiles required of new BIM roles is possible by identifying current competencies found in the roles of the work team, and the characteristics of each of the professionals that the office currently has. This selection should first be made with reference to personal and collaborative work skills, followed by technical knowledge; it is easier to train technical skills than soft skills"* BIM implementation requires engaging qualified personnel who are selected considering various criteria.

Consequently, it evidences that BIM plays a considerable role in using multi-criteria decision aid methods for selecting the most appropriate person for the project team. However, the evidence on the BIM proficiency in increasing usage of this selection method for engaging suitable members to the team has not been revealed through the existing information.

While elaborating the ways of selecting team members for BIM implementation, ONM2 with their statement *"a BIM test doesn't have to be elaborate, but you should have one"*, emphasized the importance of having a psychometric test when selecting a suitable person to a project team. Though this opinion convinces the inspiration of BIM technology in having psychometric tests for selecting the best suited candidate with required knowledge and experience, obtainable information within the industry does not substantiate the BIM significance in improving the psychometric test usage for selecting the project team members.

4.3.5 BIM as an aid for increasing levels of trust within the team

With their statement *"the key to BIM is trust"*, ONM3 emphasizes the support of BIM implementation in a project to increase the trust levels among the team members. Improving amicability of partners; encouraging contractual agreements; improving mutual interests, shared vision and ideas of collaborative sharing; encouraging care for team members; proper management of employees; proper team composition; and encouraging frequent and meaningful interactions are the main techniques identified through the literature review for increasing levels of trust within a project team. The techniques discussed under this focus can be presented in a code structure as in figure 4.6.

According to GP3, as the whole interface of BIM is web based, the physical location of the users does not impact on its implementation. However, as per the research findings of RP16, working from distance reduces the interaction among project team members making it impossible to maintain care within team members. Therefore, it become obvious that BIM does not support improving care among team members of a construction project.

Figure 4.6: Coding structure for techniques for increasing levels of trust within the team (Refer Appendix H for the full coding structure)

In their website, WS7 has published a sample agreement evidencing the motivation of BIM in establishing contractual agreements among team members of a construction project. Further, WS8 affirms this detail by their statement *"the creation and use of a building information model must be supported by contracts that properly allocate or share risk and liability among those responsible for it".* Moreover, WS9 stated that *"when embarking on a BIM-enabled project, it is important to develop a clear vision for ownership and get agreement from the various contracted parties".* Additionally as stated by PCB1, *"in BIM, all major stakeholders have a direct contractual relationship with each other and they will have enforceable obligations between them"*. Hence, the requirement of having proper contractual agreement among team members is further emphasized. However, according to ONM4 and RP14, standards for contractual agreements among team members in a BIM implemented project are not yet established in the industry. Thus, it can be identified that requisite of contractual agreement among team members is encouraged by a BIM implemented project to a limited extent.

As explained by WS10, as BIM is an automated system, changing a project team member in a BIM implemented project extends beyond the administration works. Through their promotion, WS16 revealed that BIM is a technology which allows the entire project team to connect in a convenient manner.

Further, by their statement *"now you can meet securely in the cloud with Autodesk Collaboration for Revit + BIM 360 Team. Connect your building project teams with centralized access to BIM project data"* they emphasize that BIM assists in having frequent and meaningful interactions among the project team members. Accordingly, it can be identified that BIM tools which provide convenient access to collaboration improves successful team interactions.

As identified by WS3, BIM which provides a virtual model for the team members to work with enables conflict detection through an automated approach. Further, in their research, RP15 revealed that BIM enables work related problem identification in the initial stage which facilitates early problem resolutions in a construction project. Therefore, it becomes obvious that in a BIM implemented project, technical conflicts are minimized due to the available automated models which discovers conflicts encouraging amicability among the team members.

In their research, RP3 stated that *"the BIM implementation plan should be aligned with company vision, mission, and the objectives it seeks to achieve through BIM implementation".* Further, according to PCB3, *"at the end of the day, it is field teams that need to contribute to the model in a consistent and trustworthy manner".* Based on the above statement, it can be recognized that BIM which is adopted to match with the team goals inspires improving mutual interest, shared vision and ideas of collaborative sharing for increasing the levels of trust within a project team members.

According to PCB6, management of employees is identified as one of the main requirements of BIM implementation. This is further assured through the statement *"senior leaders should guide and sustain the organization towards its BIM adoption"* by GP2 which imitates the necessity of proper management of employees in a BIM adopted project. In addition, in their research, RP3 stated that *"it is important to note that BIM roles assign responsibilities and functions to different members of the work team; they are not necessarily related to specialties or positions, and moreover, they can be developed by more than one person or allow one person to exercise more than one role".* This statement replicates the importance of team composition when implementing BIM technology in a construction project.

However, existing team management knowledge under BIM technology does not specifically reveal its extensiveness for proper management of employees and necessity of proper team composition of a construction project when compared to the projects without BIM adoption.

4.3.6 BIM for establishing effective problem solving mechanisms

In their research, RP17 has identified BIM which assists decision making process is a technology of problem solving in the construction industry.

As discovered from the literature review, proper management of resources; network creation; corporative trainings; team building; providing effective leadership; engaging team members who can use collective cognitive components; encouraging to obtain new knowledge, new information, and creative ideas; establishing transparent communication; implementing a solid foundational strategy are some of the main techniques used for establishing effective problem solving mechanisms to minimize disputes among team members that arise due to team diversity.

The techniques referred under establishing effective problem solving mechanisms can be illustrated in a coding structure as in figure 4.7.

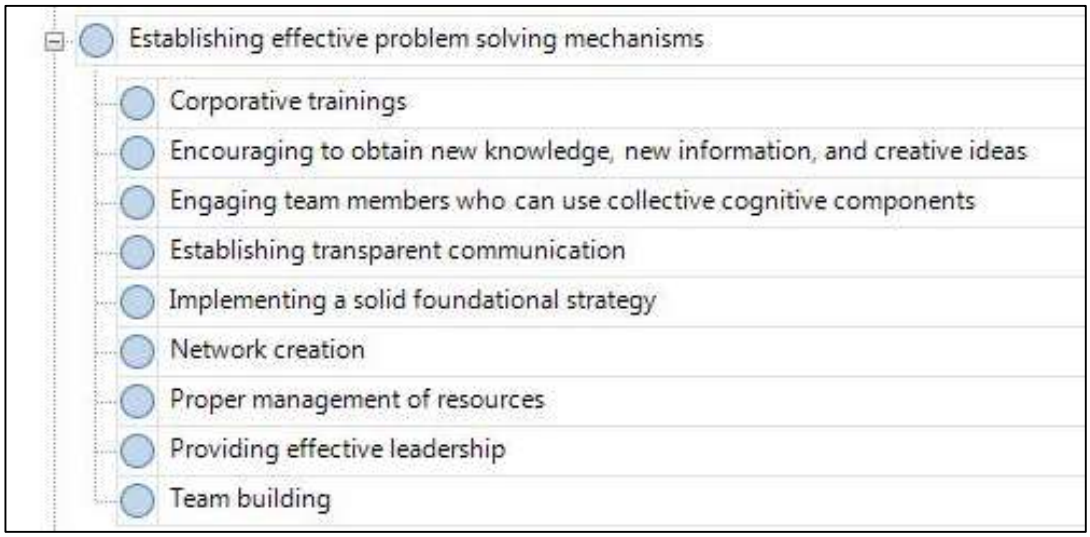

Figure 4.7: Coding structure for techniques for establishing effective problem solving mechanisms (Refer Appendix H for the full coding structure)

By their statement *"organizations which switch to BIM for the first time are in need of an extensive training that is most suitable to their process and industry, without which they will end up spending a lot of time and money and not still equipped to implement BIM",* WS12 indicated that corporative trainings becomes an essential component in proper implementation of BIM technology in a construction project. Further, according to WS16, BIM training programmes can reduce many complexities of projects that may arise while using BIM. Therefore, it becomes obvious that being a pre-requisite of BIM implementation, corporative trainings are comparatively increased by BIM adoption which facilitates effective problem solving in a construction project.

As identified by RP20, *"the main characteristics of BIM include illustrating 3D CAD-based presentations, keeping information in digital format, and facilitating the easy updating and transfer of information in a BIM environment".* This statement evidences that BIM is a technology that simplifies information sharing. Consequently, BIM allows the project team members to obtain new knowledge and information relevant for the project. Further, RP21 stated that *"for architects, BIM has the potential to optimize their creativity while reducing risk in the design and construction process, thus giving them a more significant role in the building process"* emphasizing the BIM encouragement in enhancing the creativity of the project team members. Therefore, it becomes obvious that adopting BIM technology in a construction project improves obtaining new knowledge, new information and creative ideas for the team members through its significant features that facilitate easy access to project information.

While explaining BIM modeling, PCB3 stated that *"it is more about exchanging information and working through the solution rather than passing information along, which is what we've done in the past. The model of the way we interact is very different".* Further, according to PCB3, team members who are engaged in a BIM implemented project are required to work collectively and collaboratively. Based on the above facts, it becomes perceptible that BIM encourage using cognitive components of the team members to work collectively.

Accordingly, it can be considered that proper implementation BIM in a project requires selection of candidates with collective cognitive component to form the project team. Nevertheless, information available in the industry do not precisely evidences the significance of BIM adoption to achieve a project team with collective cognitive component.

In their publication, ONM3 stated that *"clear and effective communication is a key ingredient to a successful project and even more so in a BIM environment, where openness and transparency between all team members is essential".* Further, according to WS14, BIM features such as ability to capture historical data on changes and revisions; and real-time data on production and costs, deliver transparency for collaboration and decision making. Moreover, PCB5 identified BIM as a solution for increasing transparency in communication within a construction project to track and communicate project changes in real time. Accordingly, it can be understood that BIM implementation in a project which provides data capturing within the model enhances transparent communication which promotes effective problem solving among team members.

In their research, RP12 has identified that BIM can act as a solid foundational strategy for resolving project related issues such as problems related to project management, problems related to contract management, problems related to supervision and problems related to construction. In addition, RP12 further explained that ability of BIM to act as a problem solving strategy comes from its capability to simulate the construction progresses and organizations in its system. Based on these research findings, it can be identified that BIM increases implementing a solid foundational strategy through its features to interpret the actual status of a project in a digital model to establish an effective problem solving mechanism among the project team members.

ONM5 stated that *"many of the new software used in BIM offers modelling technology that lets network managers group the network devices, application and web servers, and databases that a business service requires as one managed unit".* Further, RP18 has identified BIM as an interface which facilitates information exchange through a network.

Moreover, as per the research findings of RP19, networks established among project team members assist in proper collaboration minimizing occurrence of project problems. Accordingly, it can be recognized that BIM technology which enhances networking among the project team members provide an effective problem solving mechanism within the project.

As per the findings of RP3, BIM implementation in a project requires proper management of resources for taking the complete advantage of the technology. Further, RP28 revealed that BIM provides platforms such as *"Auto Desk- BIM 360 Team"* which facilitates convenient resource management of the project. Moreover, WS11 recognized that BIM enables effective resource management through its unique features making it obvious that BIM is a technology which has tools to promote proper resource management.

Further to the identification in subsection 4.2.2, when it comes to the leadership qualities that derive from BIM implementation, RP12 stated that *"not every member of the project team needs to display leadership in the wider project context, but leadership more generally was a commonly identified soft-skill requirement in a BIM environment".* Further, RP12 explained that in a BIM implemented project, the team members are considered to have their own areas of responsibility as project decision making is made in the context of a shared information model. Though it becomes obvious that BIM implementation in a project requires leadership qualities to emerge, the available data does not prove the extensive sustenance of BIM implementation to obtain effective leadership.

WS13 stated that *"through having one integrated design model, BIM helps to build one team as every aspect of a building, road or tunnels construction is fully considered alongside other interfaces".* This statement replicates that BIM encourage team building in construction projects to facilitate collaboration among team members. Therefore, it becomes obvious that implementing BIM in a construction project which provides an unified design model results in improving team building which becomes an effective problem solving mechanism.

4.3.7 BIM for encouraging intellectual disagreement

As revealed by the literature review, intellectual disagreement which assist in minimizing disputes among project team members that arise due to its diversity can be achieved by techniques such as establishing effective communication; exploring the reasons for disagreement within team members; understanding personalities of other team members; gathering data on the view point; providing provisions for questioning; encouraging listening; sharing viewpoints and guiding to seek common grounds. These techniques are well understood through the summarized coding structure as given under figure 4.8.

Figure 4.8: Coding structure for techniques for encouraging intellectual disagreement mechanisms (Refer Appendix H for the full coding structure)

As stated by RP23, "*the information of the properties can be accessed when needed by any stakeholder. This important feature of BIM allows stakeholder access to information and combinations of information to which they have never before easy access".* Further, in their research, RP24 explained that BIM supports all team members including the owner to understand the project. As stated by RP24, *"BIM can help ease the owners into the world of their project".* Accordingly, effectiveness of communication and information exchange which is enhanced by BIM technology due to its unique ability to provide shared model can be recognized.

As revealed by WS15, using BIM can provide online platforms for group discussions as illustrated in figure 4.9.

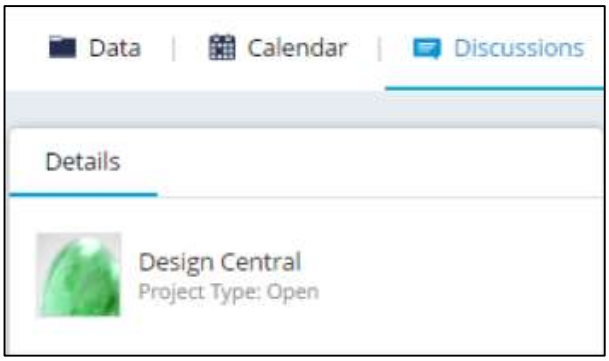

Figure 4.9: Example foe interface for group discussion within BIM technology
Source: (WS15-Autodesk Inc., 2019).

Further, using this option, project team can share their viewpoints, provide provisions for questioning, gathering data on the view point, exploring the reasons for disagreement within team members and seek common grounds. Therefore, it is evidenced that with its communication tools, BIM increases group discussions among the project team to share information as well as resolve project issues.

Through their research, RP26 discovered that for proper implementation of BIM technology in a project, the BIM team members should possess competencies such as ability to recognize others' skills and positions within a team which directs towards understanding the personalities of other team members. Moreover, RP26 has recognized proper communication skills including listening skills as one of the main competencies required for a BIM team member. However, RP26 further revealed that the ability to advance these skills gets limited depending on the virtual nature of the project team as well as the capacity of the industry to establish BIM career role standards. Therefore, based on the above findings, it becomes obvious that existing knowledge does not provide adequate evidence to identify the BIM significance to facilitate the team members to develop skills such as listening and understanding other members' personality which enables intellectual disagreement.

Accordingly, the summary of the data collection and analysis can be tabulated as in the table 4.1. According to the table 4.1 (See Appendix I), among the forty eight (48) techniques that can be used to minimize disputes arising due to team diversity which were identified through the literature review, forty (27) techniques are encouraged through BIM application in a construction project.

Further, six (19) techniques were supported by BIM technology subject to limitations and two (2) techniques were recognized as non-supported by BIM implementation. After identifying the BIM supportiveness to encourage dispute minimization techniques it becomes important to develop the conceptual framework to direct the study towards its research aim. Therefore, the subsequent section explains the development of conceptual framework with the research findings.

4.4 Development of conceptual framework

Subsequent to elaborating research findings and analysis, the development of conceptual framework was carried out by combining the findings on fundamentals of conceptual framework of the study demonstrated under figure 2.4 and research findings and analysis under section 4.3. Accordingly, the developed conceptual framework based on the literature findings and qualitative observational study can be illustrated as in table 4.2. The developed conceptual framework noticeably demonstrates the main methods of minimizing disputes arising due to team diversity which were identified by a thorough literature review.

Since these methods were extracted from a list of repetitions recognized through an in-depth literature review, it can be considered that the main dispute minimization methods in relation to the diversified nature of team members are limited to the identified methods. Accordingly, there are seven (7) main methods available in practice for minimizing disputes among project team members that arise due to the team diversity. However, this number was reduced to six (6) when the framework was further developed based on the applicability of BIM tools and features for improving existing dispute minimization techniques.

Representing the next stage of the research study, the subsequent division illustrates the existing techniques used for minimizing the disputes among the project team members which can be improved by BIM adoption in the project. These techniques identified through the literature survey and data analysis are listed against the main dispute minimization methods which were disclosed through the study.

Table 4.2: Conceptual framework

Methods of minimizing disputes led by team diversity	***BIM applicability for improving implementation of dispute minimization methods***
Encouraging team work	BIM provides a common platform which facilitates simultaneous working ability. This BIM feature enables an extensive corporative working environment to the team members to encourage team work. BIM feature which facilitates collaboration of works enhances positive interdependent team environment that promotes team work. Construction project teams which involves members in different disciplines can be benefited by BIM technology as assigning specific responsibilities becomes a feature that can be undeniably expected while implementing BIM technology in a project. This feature assists in improving team work capabilities of the team members. Information sharing and collaborative work environment which is provided by BIM implementation contributes for providing supervision of team members to encourage team work.
Establishing a vision and providing goals formed by a central scientific idea	BIM ability to simulate actual progress of the site in a shareable digital model can improve feedback process on executed work. This feature can assist in maintaining the project direction towards its ultimate goal. Assigning relevant roles and responsibilities to the members of a project team which provides a substantial foundation to sustain project goals is identified as a pre-requisite for implementing BIM technology in a project. Establishing the manner of project execution is a pre-requisite for implementing BIM. This BIM feature enhances demonstrating processes within the project which ensures the goals are established through a central scientific idea.

Table 4.2: Conceptual framework (Cont'd)

Methods of minimizing disputes led by team diversity	***BIM applicability for improving implementation of dispute minimization methods***
Establishing a vision and providing goals formed by a central scientific idea (Cont'd)	BIM simulates the actual events of the project. This feature improves the ability of explaining team work progression to the individuals to establish goals within the project. BIM provides a good medium of communication among team members through a shared platform. Therefore, BIM technology improves the proper communication among project team members which ensures establishing common goals within the project.
Creating good communication within project teams	The ability for exchanging a virtual information model with real time data among the team members assures that BIM technology can drive a project team to establish a better communication network. Training is an essential pre-requisite for BIM implementation. This requirement directs team members to improve communication within the team.
Increasing levels of trust within the team	Automated models created by BIM technology facilitates minimizing technical conflicts of the projects. This BIM feature encourages amicability among the team members which increases trust within the team. BIM implementation is done in a manner to map the project goals. This feature enhances mutual interest, shared vision and ideas of collaborative sharing for increasing the levels of trust within a project team members. BIM tools which provide convenient access to collaboration improve successful team interactions for increasing trust levels within the team.
Establishing effective problem solving mechanisms	BIM platforms such as "Auto Desk- BIM 360 Team" facilitates convenient resource management of the project. This BIM feature encourages proper resource management to establish effective problem solving mechanisms. BIM implementation increases networking among the project team members. This feature promotes establishing effective problem solving mechanism within the project.

Table 4.2: Conceptual framework (Cont'd)

Methods of minimizing disputes led by team diversity	***BIM applicability for improving implementation of dispute minimization methods***
Establishing effective problem solving mechanisms (Cont'd)	Being a pre-requisite of BIM implementation, corporative trainings are comparatively increased by BIM adoption which enables effective problem solving in a construction project. BIM provides a unified design model which improves team building. This feature simplifies establishing effective problem solving mechanisms. Easy access to project information is a significant feature of BIM technology which facilitates improving acquisition of new knowledge, new information and creative ideas for the team members. This feature assists in establishing an effective problem solving mechanism. BIM implementation provides data capturing within the project model. This BIM feature enhances transparent communication which promotes effective problem solving among team members. BIM increases implementing a solid foundational strategy through its features to interpret the actual status of a project in a digital model. This significant BIM feature enables establishing an effective problem solving mechanism among the project team members. BIM has a unique ability to provide shared models of a project. This feature enhances effectiveness of communication and information exchange among team members which promotes establishing effective problem solving mechanisms.
Encouraging intellectual disagreement	BIM provides communication tools which increases group discussions among the project team to share information and provides high access to information to establish effective communication. This feature encourages intellectual disagreement. Common platform provided for group discussion through BIM technology increases the probabilities for sharing viewpoints among team members for promoting intellectual disagreement.

After extracting from a repetitive collection of techniques which were recognized through a thorough literature survey, the main techniques available for minimizing disputes within a project team due to its diversity were interpreted in the conceptual frame work.

Consequently, forty four (44) techniques were recognized as main dispute minimization techniques used in the construction industry for minimizing disputes arising due to team diversity. However, after a careful consideration led by the data analysis, only the techniques with potential to improve dispute minimization using BIM technology were selected for the framework development which limited the total number of successful techniques to twenty four (24). Accordingly, applicability of BIM features and tools to implement the identified techniques were notified based on the discussions carried out in the research findings and analysis.

With the completion of development of the conceptual framework of the study, it becomes essential to validate the research out come with the assistance of input from experts of the field. Therefore, the research findings that were developed through the conceptual framework were validated through expert opinions as discussed in subsequent section.

4.5 Validation of the research outcome

Development of the conceptual framework to achieve the research aim generates the necessity for validating the research outcome to ensure the precision. Therefore, a semi-structured interview was carried out in accordance with the procedure explained in the sub-section 3.4.1. The analysis of the collected data from the expert interviews can be presented accordingly.

Encouraging team work

As revealed by the expert interviews, cooperativeness is identified as one of the main features of BIM implementation which results in open communication. Further, some experts recognized this feature as subjective.

Simultaneously, it was discovered that open communication introduced through BIM can expose the project to negativity by providing excessive access to information which is however can be controlled within the system. Nevertheless, overall opinion of the experts proven that BIM which facilitates simultaneous working ability encourages team work by providing an extensive corporative working environment.

Based on the findings through expert interviews, with no disagreement, it was established that the collaboration provided through BIM level 2 which enhances positive interdependent team environment can promote team work.

While revealing their opinion, some experts stated that BIM can improve assignment of work responsibilities within a digitalized environment. Further, based on his experience, an expert explained that BIM allows transferring responsibilities for several projects within a given time period encouraging people to adopt the assigned role. Additionally, expert opinions revealed that awareness of roles and responsibilities of each other leads to a team environment with lessened disputes.

As per the interviewees, client can successfully supervise the other members of the team when BIM is implemented within a project. In addition, enhanced site supervision can also be expected in a BIM implemented project. Further, BIM promotes real time supervision which can be done using new technological devices.

In addition, it was revealed that access to work history, 3D model of works, augmented reality, digitally monitored copies of works which is facilitated by BIM usage greatly assists supervisors to monitor works of other employees compared to the traditional practice. Moreover, it was established that digitalized models and high level of information availability improves supervision within project team which encourages team work.

Establishing a vision and providing goals formed by a central scientific idea

It was the opinion of one expert that the only the goals which relate to collaboration can be supported by BIM through proper monitoring and providing an opportunity to get more informative decisions. Further, experts revealed that BIM platform facilitates simulating actual progress of site which ultimately lead the project towards its goal.

In addition, it was discovered that advanced technologies such as ‘laser scans’ which displays mislaid items from the actual work compared to the 3D model making; or simple applications such as MS Excel can be used for providing feedback using BIM. Accordingly, it was identified that BIM enables an improved feedback process which drives the team members towards the project goal.

While sharing their opinions, experts revealed that assigning roles in an effective manner becomes essential when it comes to BIM implementation. Further, one interviewee explained that this feature results in lessening team members due to reduced paper works within the project. Moreover, as per the experts, this is practically achieved in a different manner compared to the traditional method by considering more coordination works. However, it was discovered that assigning relevant roles and responsibilities requires human involvement as BIM platform does not directly provides that facility. Accordingly, it was proven that BIM can lead the team members towards its project goal through its enhanced facility to define roles and responsibilities.

It was the expert view that manner of project execution need to be property established while implementing BIM in a project. Further, this process which is familiarized through experience and practice ensures the goals are established through a central scientific idea.

BIM ability of explaining team work progression to the individuals to establish goals within the project was inarguably agreed by the experts confirming the enhanced value of BIM implementation in dispute minimization.

While discussing the BIM feature to act as a good communication medium, experts identified that new technologies including using IOT (Internet of things) devices that can be adopted in BIM improves communication within the project team. However, it was revealed that this benefit will only effective provided that the LOD (Level of development) is properly defined by the management as the project goal. Accordingly, the BIM assistance in improving communication among team members to direct the project towards its goals was emphasized.

Creating good communication within project teams

When disclosing their opinions regarding the BIM capability for exchanging a virtual information model as a communication medium, experts highlighted the effect of time zones of communication on decision making. Further, improved communication was identified as one of the main objectives of BIM which allows to monitor the progress in real time and provides successful information sharing. In addition, an expert emphasized that this feature can be effective only in online systems which can be expected within BIM level 2 standard. Therefore, experts agreed that BIM technology can drive a project team to establish a better communication network.

As per the expert interviewees, the training provided before BIM implementation becomes essential to obtain a better outcome from the technology. Further, it was the opinion of an expert that training can become an 'ice breaking' if it is done after selecting the team members. That directly affects the improvement of team communication. Therefore, effectiveness of training depends on the type of training. However, even though a compulsory training requirement exists, it was the idea of majority that the communication improved through training cannot be considered as a unique result of BIM implementation.

Increasing levels of trust within the team

As per the expert opinions, errors cannot be veiled in a BIM implemented project as there is transparency of the works done by each member. This results in reducing conflicts by encouraging amicability among the team members which increases trust within the team. Further, according to an expert, the number of technical conflicts that can be identified by using BIM is only reduced in the construction phase. Accordingly, it was established that BIM encourages amicability among the team members which increases trust within the team.

Experts revealed that BIM allows the programme to be mapped to achieve project goals which ensures mutual interest, shared vision and ideas of collaborative sharing for increasing the levels of trust within a project team members.

It was the opinion of experts that the information asymmetry gets considerably reduced by BIM implementation. Further, BIM tools itself have features such as work sharing. Therefore, it was established that BIM tools which provide convenient access to collaboration improve successful team interactions for increasing trust levels within the team. However, it was revealed that attitude and personal commitment of team members may have an influence on the success of achieving this benefit through BIM implementation.

Establishing effective problem solving mechanisms

As explained by the experts, BIM facilitates to identify the accurate details of resource requirements resulting reduced wastage. Further, it was revealed that there are advanced technological tools to monitor skill levels of the engaged people. Accordingly, it was agreed that convenient resource management provided by BIM encourages proper resource management to establish effective problem solving mechanisms.

When discussing about networking, experts stated that BIM provides a positive networking background depending on the team arrangement. Therefore, with no argument, it was established that BIM implementation increases networking among the project team members promoting effective problem solving mechanisms within the project.

When it comes to trainings within BIM teams to establish effective problem solving mechanisms, it was the opinion of an expert that implementing BIM level 2 itself does not require training due to its advanced nature. However, it was the opinion of majority that knowledge sharing sessions exists within BIM implementation where standards are upgraded by trainings. Moreover, it was recognized that trainings becomes essential for proper usage of BIM tools. In addition, an expert stated that training is a subjective requirement where problems should be purposefully addressed within the training programme.

It was with no argument agreed that BIM provides a unified design including model 3D images which can be obtained before site construction is completed, simplifies establishing effective problem solving mechanisms.

As per an expert, easy access to project information allowed by BIM technology can only be effective for establishing an improved problem solving mechanism if the proper personnel are engaged within the team. However, it was the majority opinion that this feature can improve problem solving within project team by providing convenient access to new knowledge and information.

As BIM provides transparent communication within team members where dishonesties are mitigated, it was the opinion of experts that effective problem solving among team members can be improved through BIM implementation.

According to the experts, provided that the LOD of the project is properly defined, BIM feature to interpret the actual status of a project in a digital model can enable establishing an effective problem solving mechanism among the project team members.

While explaining the unique ability of BIM implementation to provide shared models of a project, an expert highlighted that model sharing is generally done among departments and not with other stakeholders unless there is an arrangement. However, it was the opinion of majority of experts that this BIM feature enhances effectiveness of communication and information exchange among team members which promotes establishing effective problem solving mechanisms.

Encouraging intellectual disagreement

As identified by the experts, BIM provides communication tools which increases group discussions among the project team to share information and provides high access to information to establish effective communication. This is further encouraged by the transparency within the team and convenience in decision making without waiting for physical meetings. Therefore, it was established that this BIM feature improves intellectual disagreement. Further, experts agreed that BIM technology simplicities group discussions increasing the probabilities for sharing viewpoints among team members for promoting intellectual disagreement.

Accordingly, for convenient reference, the interview outcome can be summarized as in table J.1 of Appendix J. As per table J.1, it becomes obvious that twenty three (23) of the twenty four (24) facts identified through the desk study have been agreed by the experts. However, based on the opinions of experts, it can be established that the fact '*Training is an essential pre-requisite for BIM implementation. This requirement directs team members to improve communication within the team*' does not qualify as a completely accurate statement. This may be due to the difference in practical exposure of the selected experts who are only familiar on the BIM practice in Sri Lanka where BIM level 2 is not firmly established.

After gathering responses from the industry experts, it becomes essential to identify and establish validity of the BIM applicability in dispute minimization among project team members. Therefore, BIM applicability for inspiring existing dispute minimization techniques has been discussed in the subsequent section.

4.6 Research difficulties

Main difficulty that occurred during conduction of this research was the lack of data sources with direct indication of the applicability of BIM technology for minimizing disputes among project team members. Due to this reason, the data sources were selected without limitations to gather data which demonstrated the applicability of BIM features to encourage selected dispute minimization techniques. Further, selection of the professional experts with both industrial and BIM technological knowledge required more effort due to geographical constraints. In order to overcome this difficulty, the number of experts involved for the validation of the research outcome was limited to five (5) professionals who are available in the research location (Sri Lanka).

4.7 Summary

This chapter had been allocated to demonstrate the details on research findings and analysis which led the study towards accomplishing its research aim through developing the suggested conceptual framework of the study.

The developed conceptual framework revealed the key methods that can be used to minimize the identified disputes and; the available techniques for implementing such dispute minimization methods which can be enhanced by BIM implementation in a project. The data collection for the study was carried out using a qualitative observational study where online data sources were selected as the primary sources. Further, content analysis was used for analyzing the collected data and based on the fundamentals for developing the conceptual framework which were identified through the literature survey in Chapter 2, the applicability of BIM technology to improve the existing dispute minimization techniques has been mapped for completing the conceptual framework. Consequently, semi-structured interviews with selected industry professionals were carried out to validate the research findings. No evidence or directives were found through this validation to alter the established framework. Accordingly, based on the interview findings, the applicability of BIM technology to minimize disputes among project team members was established. The next chapter concludes the study with conclusions and recommendations.

CHAPTER 05

CONCLUSIONS AND RECOMMENDATIONS

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5.1 Introduction

Previous chapter of the study revealed the analysis and discussion of the collected data through a qualitative observational study which was carried out using selected online sources; and expert interviews carried out to validate the developed framework. Accordingly, this chapter aims on identifying the key findings of the study which directs the research findings towards the conclusions and recommendations. Firstly, the research problem is established based on the literature review which demonstrated the fundamentals of conceptual framework of the study. Additionally, these findings are further described with a cognitive map (See Appendix K) for better understanding of the study. Consequently, the research findings which were extracted from the content analysis of the collected data from qualitative observational study are elaborated with reference to the validated framework with the intention of providing a certain basis for achieving the ultimate objective of the study. Subsequently, the recommendations recognized through the findings of the study are offered in terms of implications to theory and implication to construction industry. Lastly, new research directions emerging from the study are identified to provide a conclusion to the study.

5.2 Summary of study

The study was focused on identifying the applicability of Building Information Modeling (BIM) for minimizing disputes arising attributable to project team diversity. This study was interesting due to the reason that there is a visible connection between dispute minimization techniques among project team members and BIM technology, it has not yet been theoretically confirmed. Five objectives had been established and implemented with the intention of achieving this aim. The first objective required determining the main sources of disputes among project team members that arise due to team diversity. A thorough literature review was carried out as the initial phase to succeed with this objective.

With the lead of identified causes of disputes, the research was focused on discovering the available methods to minimize disputes that arise due to diversified nature of the project team members, to achieve the next objective of the study.

Accordingly, encouraging team work; establishing a vision and providing goals formed by a central scientific idea; creating good communication within project teams; engaging qualified and experienced personnel; increasing levels of trust within the team; establishing effective problem solving mechanisms; and encouraging intellectual disagreement were identified as the main methods of minimizing disputes arising due to team diversity that existing in the construction industry. Subsequent to identifying the main methods of minimizing disputes, the main techniques to implement the recorded methods of minimizing disputes caused by team diversity were discovered through the literature review in order to achieve the succeeding objective. Accordingly, the fundamentals for developing the framework to achieve the research aim were established with the use of an in-depth literature review.

As the subsequent step to drive the research towards its ultimate aim, a qualitative observational study was carried out using online sources including research publications, online forums, online discussions at professional networks, personal and company blogs, websites, online newspapers, online magazines, and BIM guidelines to explore the interconnection between BIM technology and the identified dispute minimization techniques. Consequently, BIM features and tools that can be used to improve the discovered techniques for minimizing disputes arising due to team diversity were identified using the data analysis which is carried out with the collected data from qualitative observational study.

The succeeding objective of the study where the expectations were to identify the applicable BIM features to improve dispute minimization techniques could be achieved by developing a conceptual framework mapping the findings from literature review and analysis of the qualitative observational study.

While identifying the techniques that can be improved through BIM implementation, the outcome of the observational study compelled omitting the techniques such as ‘inquiring concerns and needs of team members’ and ‘encouraging commitment to the goal’ which were identified through the literature review due to insufficiency of available information. Further, based on the data analysis, the applicable BIM features and tools for improving the available dispute minimization techniques were identified as in table I.1 (See Appendix I).

Fulfilling of the latter objective inspired the research for achieving the final objective of the study where the research findings were validated by expert interviews to confer recommendations on applicability of BIM technology for minimizing disputes among construction project team members that arise due to team diversity. In order to accomplish this objective, five interviews were carried out with industry experts with the intention of validating the framework developed using the literature review and qualitative observational study. The expert opinions revealed minor considerations to not fully agree on the research findings. However, any solid argument to refuse the findings of developed conceptual framework was not established. Accordingly, it can be identified that the findings and analysis of expert interviews affirmed the applicability of BIM technology in improving each identified technique to minimize disputes among project teams that arise due to the diversified nature of the team members. This summary directed the research towards accomplishing the ultimate goal of the study where the applicability Building Information Modeling (BIM) for minimizing disputes arising attributable to project team diversity was identified. The final outcome of the study which can be used for future reference can be summarized as in table 4.3.

5.3 Recommendations

The applicability of the research findings can be identified against the implications to theory and practice within the construction industry as elaborated in the subsequent subsections.

5.3.1. Implications to theory

While achieving the ultimate aim of the research, a basis is established to identify the applicability of BIM technology to act as an assistance in minimizing disputes that arise due to diversified nature of the team members. Accordingly, as the contribution to theory, the research has bridged the gap between BIM technology and minimization of disputes arising due to diversified of nature of team members.

5.3.2. Implications to construction industry

The outcome of the research study revealed a center where the applicability of BIM technology in building construction projects to minimize disputes arising due to diversified nature of members. The findings of the study become substantial to be implicated within the construction industry due to various drives. As per the objectives of the research, the outcome of the study can be used in identifying the applicability of BIM technology in minimizing the disputes among team members of construction projects. In addition, the developed conceptual framework reveals the dispute minimization techniques that can be enhanced through BIM implementation. As BIM implementation comes with more impediments, the study outcome provides a motive for the construction industry to adopt BIM technology to evaluate its benefits over the obstacles. Further, as the study has revealed the causes of disputes arising due to team diversity, the team members can become aware of such future occurrences which would benefit them obtaining a rational understanding of similar circumstances.

5.4 Limitations of the research

The literature review exposed the study towards identifying a vast number of minimization methods and techniques related to disputes arising due to the diversified nature of team members. Therefore, the main methods and techniques had to be extracted and summaries in order to avoid the repetition and extremeness of information. However, the techniques which were not considered under the study due to less impact on non-BIM context may have a considerable impact on circumstances where BIM is adhered. Further, the qualitative observational study was carried out based on the resources available online.

In addition, study included only publications in English and due to using particular keywords while data collection, information may have been omitted or neglected from relevant studies.

Some techniques available within the industry for minimizing disputes arising due to team diversity that were revealed through the literature review could not be recognized through the qualitative observational study. This was resulted by the limited reliable online resources which indicate information referring to a connection between dispute minimization and BIM implementation.

Since this research focuses on BIM technology which is currently limited to the building construction industry, only the teams related to the building construction projects has been referred.

Further, while defining the project teams, the members who are directly involved with a construction project are identified as the team members to avoid misperception. In addition, as the features and outcome of BIM implementation can differ based on the adopted BIM level, for the purpose of study, BIM level 2 was identified as the BIM technology.

5.5 Further research directions

After identification of the research outcome, it becomes important to explore further research directions as discussed subsequently.

Consider minor techniques of dispute minimization

Since the study is limited to consider the main dispute minimization techniques, in order to avoid disregarding substantial techniques that may have an impact on BIM implemented techniques, a further study can be carried out considering all available dispute minimization methods in the industry.

Focus on disputes among team members that may arise due to technical and contractual aspects

Although the research had been only focused on the disputes arising due to the diversified nature of team members, the study can be further developed by directing the area towards the contractual and technical aspects which can cause disputes among project team members.

Verifying the effectiveness of using BIM features and tools for dispute minimization

The study discovered the applicability of BIM features and tools for improving dispute minimization within a project team. In order to provide a complete basis on the BIM application, a further study can be carried out to investigate the effectiveness of BIM usage for dispute minimization to achieve the maximum benefit throughout the project.

A study to reveal the applicability of BIM features and tools for dispute minimization to extended project teams

As the study has only focused on team members who are directly involved in the project, a further research can be conducted to extend the focused group to include stakeholders with indirect involvement.

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APPENDICES

Appendix A: Main causes of disputes among project team members arising due to its diversity

Table A.1: Main causes of disputes among project team members arising due to its diversity

IS	Cause of disputes arising due to team diversity	Reference
c.1	Difference in interests	Cherns and Bryant (1984) and Butler (1973)
c.2	Culture	Cheung et al. (2006)
c.3	Communications	
c.4	Opposition of interests	
c.5	Opposition of values	
c.6	Opposition of objectives	
c.7	Difference in perspectives	
c.8	Difference in interests	
c.9	Difference in agenda of human beings	
c.10	Incompatibility of two (or more) people's (or groups') interests	
c.11	Incompatibility of two (or more) people's (or groups') needs	
c.12	Incompatibility of two (or more) people's (or groups') goals	
c.13	Lack of team spirit	
c.14	Misunderstandings	
c.15	Competitive/ adversarial attitude by the participants	
c.16	Dissimilar perceptions of fairness by the participants	
c.17	Opportunistic behavior	
c.18	Facts	Greenburg (2011)
c.19	Definitions	
c.20	Values	
c.21	Signaling	
c.22	Failures of logic	
c.23	Information processing methods	
c.24	Default beliefs	
c.25	Self-interest	
c.26	Communication gap among project team members	Rameezdeen and Gunarathna (2003)
c.27	Conflicts within relationship among parties	Gamero et al. (2008) and Barsade et al. (2000)
c.28	Allocated task	Gamero et al. (2008)
c.29	Formation of clashes among the contractual parties	Cheung et al. (2006)
c.30	Opportunistic behavior	Love et al. (2008)
c.31	Divergent interests of team members	Cheung and Pang (2013)
c.32	Adversarial (industry) culture	Kumaraswamy (1997)
c.33	Lack of competence of project participants	
c.34	Lack of professionalism of project participants	
c.35	Client's lack of information or decisiveness	
c.36	Unrealistic information expectations by the contractors	
c.37	Poor communications	
c.38	Personality clashes	
c.39	Varied interests	

Appendix A: Main causes of disputes among project team members arising due to its diversity

Table A.1: Main causes of disputes among project team members arising due to its diversity (cont'd)

IS	Cause of disputes arising due to team diversity	Reference
c.40	Cognitions of the people involved	Garcia-Prieto et al. (2003)
c.41	Behaviors of the people involved	
c.42	Emotions of the people involved	
c.43	Task interdependency	Gardiner and Simmons (1998)
c.44	Organizational differentiation	
c.45	Values, interests and objectives	
c.46	Tension	
c.47	Personal traits	
c.48	Communication obstacles	
c.49	Uncooperativeness	Younis et al. (2008)
c.50	Slowness of decision making process	
c.51	Inadequate communication	
c.52	Influence from social and cultural factors	
c.53	Lack of communication	Bristow and Vasilopoulous (1995)
c.54	Lack of team spirit	
c.55	Negligence	Colin et al. (1996)

Appendix B: Existing methods of minimizing disputes arising due to team diversity

Table B.1: Existing methods of minimizing disputes arising due to team diversity

IS	Method of minimizing disputes arising due to team diversity	Reference
m.1	Team working between the construction project team members	Latham (1994)
m.2	Collaborative working between the construction project team members	
m.3	Partnership between the construction project team members	
m.4	Meeting regularly either physically or virtually	Bennett and Gadlin (2012)
m.5	Establishing a vision and providing goals formed by a central scientific idea	
m.6	Communicating effectively	
m.7	Encouraging intellectual disagreement	
m.8	Encouragement on working together	Yates and Epstein, (2006)
m.9	Encouraging to treat other members equally	Moore and Dainty (2001)
m.10	Promoting cooperation	Gardiner and Simmons, (1998)
m.11	Establishing good relations	
m.12	Increasing levels of trust within the team	Loosemore et al. (2000)
m.13	Establishing effective problem solving mechanisms within a project team	Mitropolous and Howell (2001)
m.14	Problem-solving	Rahim (1983)
m.15	Smoothing	
m.16	Forcing	
m.17	Sharing	
m.18	Alignment of attitudes within project team	Baiden et al. (2006)
m.19	Communication	
m.20	Ensuring delivery of right information to the appropriate person at the right time	
m.21	Encouraging acceptance instead compliance from members to share a common vision with leadership	
m.22	Engaging qualified personnel	Vaaland (2004
m.23	Appointing persons with work experience	
m.24	Responding to problems in a timely manner	Rauzana (2016)
m.25	Creating good communication within project teams	
m.26	Creating a clear mechanism	
m.27	Creating management and good supervision.	
m.28	Enhancing the understanding of other party's perception	Vaaland (2004)
m.29	Stimulating openness	
m.30	Reducing relational uncertainty	
m.31	Analyzing problematic issues before escalating the tension	
m.32	Open confrontation of differences	Lawrence and Lorsch, (1967)

Appendix C: Relationship among causes of disputes that arise due to team diversity and available dispute minimization methods

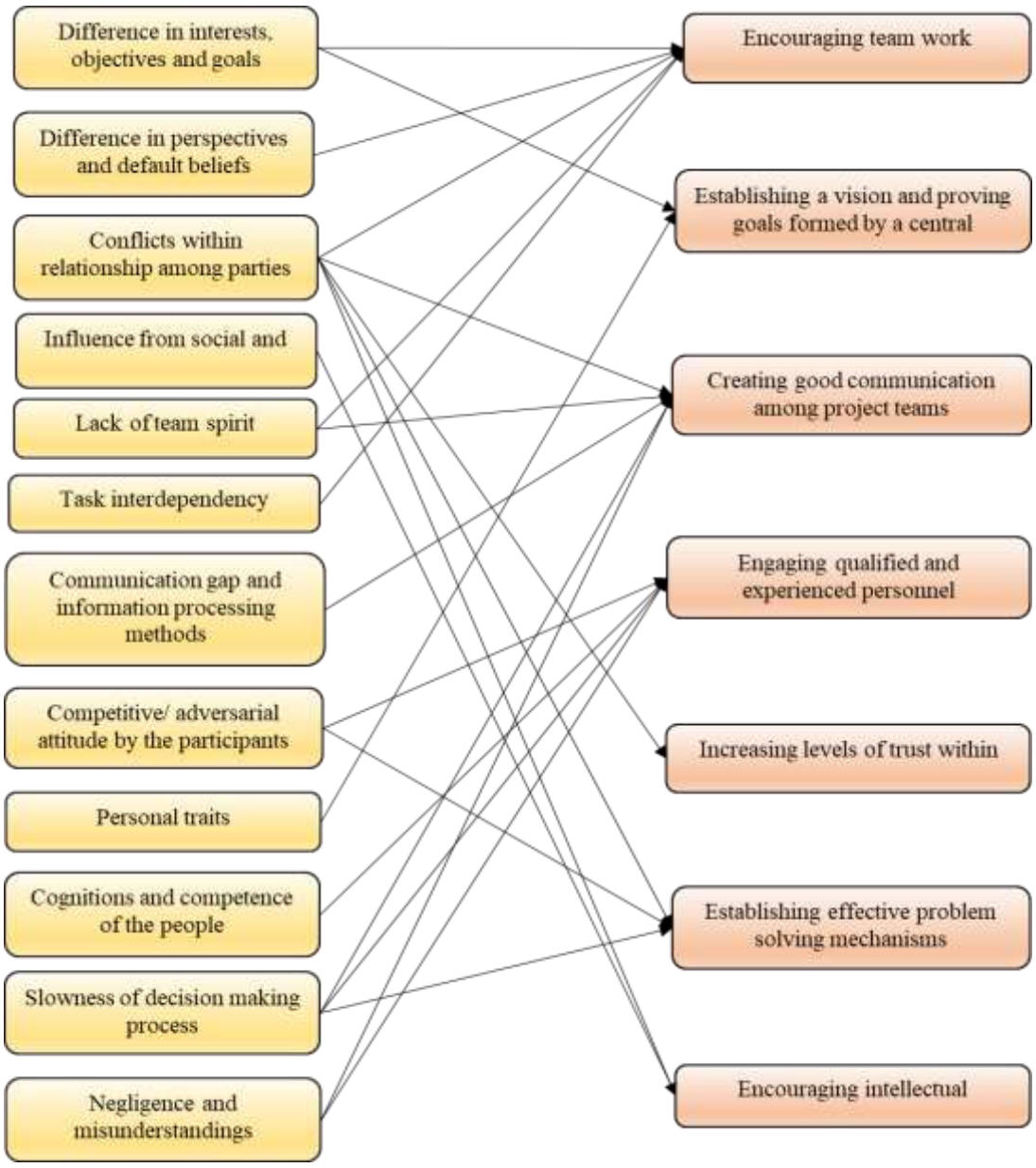


Figure C.1: Relationship among causes of disputes that arise due to team diversity and available dispute minimization methods

Appendix D: Techniques for implementing minimization methods related to disputes arising due to team diversity

Table D.1: Techniques for implementing minimization methods related to disputes arising due to team diversity

Dispute minimization method	IS	Technique for implementation
Encouraging team work	t.1	Providing cooperative working environments
	t.2	Providing positive interdependent team environment
	t.3	Assigning specific responsibilities
	t.4	Inquiring concerns and needs of team members
	t.5	Valuing team members' contribution
	t.6	Supervision
Establishing a vision and proving goals formed by a central scientific idea	t.7	Feedback
	t.8	Commitment to the goal
	t.9	Task complexity
	t.10	Situational constraints
	t.11	Assigning roles and responsibilities
	t.12	Demonstrating processes
	t.13	Explaining team work progression to the individuals
	t.14	Facilitating proper communication among project team members
	t.15	Strong leadership
Creating good communication within project teams	t.16	Increasing strength of personal contacts
	t.17	Holding meetings
	t.18	Establishing communication networks
	t.19	Providing leadership
	t.20	Providing training, developing and support for improving communication
Engaging qualified and experienced personnel	t.21	Holding interviews
	t.22	Using group decision approach
	t.23	Using psychometric tests
	t.24	Using multi-criteria decision aid methods
Increasing levels of trust within the team	t.25	Improving amicability of partners
	t.26	Encouraging contractual agreements
	t.27	Improving mutual interests, shared vision and ideas of collaborative sharing
	t.28	Encouraging care for team members
	t.29	Proper management of employees
	t.30	Proper team composition
	t.31	Encouraging frequent and meaningful interactions
Establishing effective problem solving mechanisms	t.32	Proper management of resources
	t.33	Network creation
	t.34	Corporative trainings
	t.35	Team building
	t.36	Providing effective leadership
	t.37	Engaging team members who can use collective cognitive components
	t.38	Encouraging to obtain new knowledge, new information, and creative ideas
	t.39	Establishing transparent communication
	t.40	Implementing a solid foundational strategy

Appendix D: Techniques for implementing minimization methods related to disputes arising due to team diversity

Table D.1: Techniques for implementing minimization methods related to disputes arising due to team diversity (Cont'd)

Dispute minimization method	IS	Technique for implementation
Encouraging intellectual disagreement	t.41	Establishing effective communication
	t.42	Understanding personalities of other team members
	t.43	Encouraging listening
	t.44	Sharing viewpoints

Appendix E: Interview Structure

INTERVIEW STRUCTURE

Interview Guideline

This interview is conducted in order to achieve a successful fulfillment of dissertation under Degree of Master of Science in Construction Law and Dispute Resolution at Department of Building Economics, University of Moratuwa. The information gathered will only be used for the purpose of this particular research and to maintain the confidentiality, actual names of the projects or the interviewees will be not be revealed in this report or any other related documents.

The interview guidelines are structured in 7 main headings as;

- General identification
- Encouraging team work
- Establishing a vision and providing goals formed by a central scientific idea
- Creating good communication within project teams
- Increasing levels of trust within the team
- Establishing effective problem solving mechanisms
- Encouraging intellectual disagreement

The interviews will be conducted with five eligible professionals of the construction industry who posses sound knowledge in BIM technology.

If the permission is granted by the interviewee, note taking and tape recording will be done throughout the interview to ensure the accuracy of collected data. The selected persons will be interviewed based on the following guidelines.

Name of the Interviewee (Optional): ……..

Current designation: ……...

Date of interview: ……...

Venue: ……

Duration: ……

Appendix E: Interview Structure

Introduction to the interview

Disputes that arise within a project team due to the diversified nature of members can lead a construction project towards negative consequences. Among the various alternatives available, this research intends to identify the possibility of using BIM (Building Information Modeling) technology for minimizing disputes that arise due to team diversity.

Researchers have identified six main methods of dispute minimization within project teams which have a potential to be improved by BIM technology. These methods include encouraging team work; establishing a vision and providing goals formed by a central scientific idea; creating good communication within project teams; increasing levels of trust within the team; establishing effective problem solving mechanisms and encouraging intellectual disagreement. With the use of a qualitative observational study, this study has discovered the applicability of BIM technology for improving the identified techniques to minimize disputes arising due to team diversity.

The interviewees are mainly expected to validate the research findings by providing reasons agreement/ disagreement / any suggestions or recommendations.

General Identification

1. How long have you been involved in the construction industry?

…….

2. How long have you studied/ used BIM technology?

…….

3. How long is your professional experience as a project team member?

…….

4. Have you confronted any disputes among project team members?

…….

Appendix E: Interview Structure

Encouraging team work

Research findings reveled the following.

Ref	BIM applicability for improving team work
i	BIM provides a common platform which facilitates simultaneous working ability. This BIM feature enables an extensive corporative working environment to the team members to encourage team work.
ii	BIM feature which facilitates collaboration of works enhances positive interdependent team environment that promotes team work.
iii	Construction project teams which involves members in different disciplines can be benefited by BIM technology as assigning specific responsibilities becomes a feature that can be undeniably expected while implementing BIM technology in a project. This feature assists in improving team work capabilities of the team members.
iv	Information sharing and collaborative work environment which is provided by BIM implementation contributes for providing supervision of team members to encourage team work.

5. Kindly explain the reasons for agreement/ disagreement / any suggestions or recommendations

i. ……
ii. ……
iii. ……
iv. ……

Establishing a vision and providing goals formed by a central scientific idea

Research findings reveled the following.

Ref	BIM applicability for improving establishment of a vision and providing goals formed by a central scientific idea
i	BIM ability to simulate actual progress of the site in a shareable digital model can improve feedback process on executed work. This feature can assist in maintaining the project direction towards its ultimate goal.
ii	Assigning relevant roles and responsibilities to the members of a project team which provides a substantial foundation to sustain project goals is identified as a pre-requisite for implementing BIM technology in a project.
iii	Establishing the manner of project execution is a pre-requisite for implementing BIM. This BIM feature enhances demonstrating processes within the project which ensures the goals are established through a central scientific idea.
iv	BIM simulates the actual events of the project. This feature improves the ability of explaining team work progression to the individuals to establish goals within the project.
v	BIM provides a good medium of communication among team members through a shared platform. Therefore, BIM technology improves communication among project team members which ensures establishing common goals within the project.

6. Kindly explain the reasons for agreement/ disagreement / any suggestions or recommendations

i. ……
ii. ……
iii. ……
iv. ……
v. ……

Creating good communication within project teams

Research findings reveled the following.

Ref	BIM applicability for improving communication within project teams
i	The ability for exchanging a virtual information model with real time data among the team members assures that BIM technology can drive a project team to establish a better communication network.
ii	Training is an essential pre-requisite for BIM implementation. This requirement directs team members to improve communication within the team.

7. Kindly explain the reasons for agreement/ disagreement / any suggestions or recommendations

i. ……
ii. ……

Increasing levels of trust within the team

Research findings reveled the following.

Ref	BIM applicability for improving levels of trust within the team
i	Automated models created by BIM technology facilitates minimizing technical conflicts of the projects. This BIM feature encourages amicability among the team members which increases trust within the team.
ii	BIM implementation is done in a manner to map the project goals. This feature enhances mutual interest, shared vision and ideas of collaborative sharing for increasing the levels of trust within a project team members.
iii	BIM tools which provide convenient access to collaboration improve successful team interactions for increasing trust levels within the team.

8. Kindly explain the reasons for disagreement / any suggestions or recommendations

i. ……
ii. ……
iii. ……

Appendix E: Interview Structure

Establishing effective problem solving mechanisms

Research findings reveled the following

Ref	BIM applicability for improving problem solving mechanisms
i	BIM platforms such as "Auto Desk- BIM 360 Team" facilitates convenient resource management of the project. This BIM feature encourages proper resource management to establish effective problem solving mechanisms.
ii	BIM implementation increases networking among the project team members. This feature promotes establishing effective problem solving mechanisms within the project.
iii	Being a pre-requisite of BIM implementation, corporative trainings are comparatively increased by BIM adoption which enables effective problem solving in a construction project.
iv	BIM provides a unified design model which improves team building. This feature simplifies establishing effective problem solving mechanisms.
v	Easy access to project information is a significant feature of BIM technology which facilitates improving acquisition of new knowledge, new information and creative ideas for the team members. This feature assists in establishing an effective problem solving mechanism.
vi	BIM implementation provides data capturing within the project model. This BIM feature enhances transparent communication which promotes effective problem solving among team members.
vii	BIM increases implementing a solid foundational strategy through its features to interpret the actual status of a project in a digital model. This significant BIM feature enables establishing an effective problem solving mechanism among the project team members.
viii	BIM has a unique ability to provide shared models of a project. This feature enhances effectiveness of communication and information exchange among team members which promotes establishing effective problem solving mechanisms.

9. Kindly explain the reasons for disagreement / any suggestions or recommendations

i. ……
ii. ……
iii. ……
iv. ……
v. ……
vi. ……
vii. ……
viii. ……

Appendix E: Interview Structure

Encouraging intellectual disagreement

Research findings reveled the following.

Ref	BIM applicability for improving intellectual disagreement
i	BIM provides communication tools which increases group discussions among the project team to share information to establish effective communication. This feature encourages intellectual disagreement.
ii	Common platform provided for group discussion through BIM technology increases the probabilities for sharing viewpoints among team members for promoting intellectual disagreement.

10. Kindly explain the reasons for disagreement / any suggestions or recommendations

i. ……
ii. ……

11. Any other comments you would like to share about BIM

……
……
……
……

I would like to thank you for the information given and time you have dedicated to this research. If you are interested to know the outcome of this research, it would be my pleasure to share it with you.

……
Final year postgraduate
Department of Building Economics
University of Moratuwa

Appendix F: Sample interview transcript

INTERVIEW STRUCTURE

Interview Guideline

This interview is conducted in order to achieve a successful fulfillment of dissertation under Degree of Master of Science in Construction Law and Dispute Resolution at Department of Building Economics, University of Moratuwa. The information gathered will only be used for the purpose of this particular research and to maintain the confidentiality, actual names of the projects or the interviewees will be not be revealed in this report or any other related documents.

The interview guidelines are structured in 7 main headings as;

- General identification
- Encouraging team work
- Establishing a vision and providing goals formed by a central scientific idea
- Creating good communication within project teams
- Increasing levels of trust within the team
- Establishing effective problem solving mechanisms
- Encouraging intellectual disagreement

The interviews will be conducted with five eligible professionals of the construction industry who posses sound knowledge in BIM technology.

If the permission is granted by the interviewee, note taking and tape recording will be done throughout the interview to ensure the accuracy of collected data. The selected persons will be interviewed based on the following guidelines.

Name of the Interviewee (Optional): -

Current designation: *BIM coordinator*

Date of interview: *05th October 2019*

Venue: *Wadduwa*

Duration: *90 mins*

Appendix F: Sample interview transcript

Introduction to the interview

Disputes that arise within a project team due to the diversified nature of members can lead a construction project towards negative consequences. Among the various alternatives available, this research intends to identify the possibility of using BIM (Building Information Modeling) technology for minimizing disputes that arise due to team diversity.

Researchers have identified six main methods of dispute minimization within project teams which have a potential to be improved by BIM technology. These methods include encouraging team work; establishing a vision and providing goals formed by a central scientific idea; creating good communication within project teams; increasing levels of trust within the team; establishing effective problem solving mechanisms and encouraging intellectual disagreement. With the use of a qualitative observational study, this study has discovered the applicability of BIM technology for improving the identified techniques to minimize disputes arising due to team diversity.

The interviewees are mainly expected to validate the research findings by providing reasons agreement/ disagreement / any suggestions or recommendations.

General Identification

1. How long have you been involved in the construction industry?

6 years

2. How long have you studied/ used BIM technology?

5 years

3. How long is your professional experience as a project team member?

6 years

4. Have you confronted any disputes among project team members?

Yes.

Appendix F: Sample interview transcript

Encouraging team work

Research findings reveled the following.

Ref	BIM applicability for improving team work
i	BIM provides a common platform which facilitates simultaneous working ability. This BIM feature enables an extensive corporative working environment to the team members to encourage team work.
ii	BIM feature which facilitates collaboration of works enhances positive interdependent team environment that promotes team work.
iii	Construction project teams which involves members in different disciplines can be benefited by BIM technology as assigning specific responsibilities becomes a feature that can be undeniably expected while implementing BIM technology in a project. This feature assists in improving team work capabilities of the team members.
iv	Information sharing and collaborative work environment which is provided by BIM implementation contributes for providing supervision of team members to encourage team work.

5. Kindly explain the reasons for agreement/ disagreement / any suggestions or recommendations

i. *'Revit' which is commonly used in BIM facilitates working environment to the project team. Same is facilitated by 'Auto CAD' but in a basic level. There are also other facilities such as 'Cloud support' that can be obtained while using BIM. BIM only explains what needs to be done. How it is done or the software/ tool that need to be used is not established within BIM concept. Those details are explained in BIM guides and protocols. Problems may occur while achieving BIM standards within a project team, but BIM does not suggest solutions. They come from practice. However, when it comes to the BIM level 2, an extensive corporative working environment can be expected within a project team. BIM 360, Aconex BIM, Oracle are some of the software which provide corporative working environment through BIM.*

ii. *Visual model provided by BIM shows the practical nature of works. For an example, draftsman can provide a more accurate product based on the Architect's instructions compared to the traditional method. BIM implementation requires collaboration. But still it does not say how to achieve it. That depends on the user. BIM features allow to see the model made with contribution of all team members and explore it before making decisions.*

Therefore, it can be said that BIM provides a positive interdependent team environment, however, based on the level it is implemented. In other words, if it is BIM level 2, we can expect a higher level of interdependency among team members than in traditional practice.

iii. *When practicing BIM, new roles such as BIM architect need to be introduced to the project team. Further, it can be said that BIM requires the project team to adhere to formalized or systematic responsibilities. Sequence of implementing these responsibilities are often different from the traditional practice. It is important note that the way BIM requires the project team members to be assigned responsibilities is well promotes team work.*

iv. *Access to work history, 3D model of works, augmented reality, digitally monitored copies of works which is facilitated by BIM usage greatly assists supervisors to monitor works of other employees compared to the traditional practice. Therefore, using BIM can obviously enhance supervision of project team members.*

Establishing a vision and providing goals formed by a central scientific idea

Research findings reveled the following.

Ref	BIM applicability for improving establishment of a vision and providing goals formed by a central scientific idea
i	BIM ability to simulate actual progress of the site in a shareable digital model can improve feedback process on executed work. This feature can assist in maintaining the project direction towards its ultimate goal.
ii	Assigning relevant roles and responsibilities to the members of a project team which provides a substantial foundation to sustain project goals is identified as a pre-requisite for implementing BIM technology in a project.
iii	Establishing the manner of project execution is a pre-requisite for implementing BIM. This BIM feature enhances demonstrating processes within the project which ensures the goals are established through a central scientific idea.
iv	BIM simulates the actual events of the project. This feature improves the ability of explaining team work progression to the individuals to establish goals within the project.
v	BIM provides a good medium of communication among team members through a shared platform. Therefore, BIM technology improves communication among project team members which ensures establishing common goals within the project.

6. Kindly explain the reasons for agreement/ disagreement / any suggestions or recommendations

i. *Advanced technologies such as 'laser scans' which shows what is missing from the actual work compared to the 3D model making; or simple applications such as MS Excel can be used for providing feedback using BIM. However, the effectiveness of feedback process depends on the BIM level that is adhered. Therefore, if BIM level 2 is adopted, it provides an improved feedback process compared to the traditional practice.*

ii. *BIM level 2 inevitably assigns responsibilities to the team members that focuses on the project goal. This is practically done different to the traditional method considering more coordination works.*

iii. *Demonstrating the project process is the ultimate goal of the project. Therefore, this feature is definitely enhanced by BIM adoption.*

iv. *Work progression of team members is easily monitored by BIM adoption. BIM level 2 standard facilitates this requirement in an advanced level compared to the traditional method. For an example, a safety officer can easily monitor the site works such as fire evacuation and tower crane usage to take necessary safety measures.*

v. *Improved communication platform is a must that can be expected from BIM adoption. Therefore, undoubtedly BIM facilitates better communication compared to the traditional method.*

Creating good communication within project teams

Research findings reveled the following.

Ref	BIM applicability for improving communication within project teams
i	The ability for exchanging a virtual information model with real time data among the team members assures that BIM technology can drive a project team to establish a better communication network.
ii	Training is an essential pre-requisite for BIM implementation. This requirement directs team members to improve communication within the team.

7. Kindly explain the reasons for agreement/ disagreement / any suggestions or recommendations

i. *Improved communication networks is an essential feature of successfully implemented BIM system. Therefore, it can be agreed that BIM usage facilitates a better communication process compared to the traditional method.*

ii. *Obtaining a training before adopting BIM in a project cannot be considered as a feature of BIM technology. Improving communication can be expected from any training programme depending on the provided type of training. Therefore, the training given for BIM cannot be totally identify as a unique way of improving communication within project team. However, it becomes important to provide a training before adopting BIM technology which completely depends on the selected team members.*

Increasing levels of trust within the team

Research findings reveled the following.

Ref	BIM applicability for improving levels of trust within the team
i	Automated models created by BIM technology facilitates minimizing technical conflicts of the projects. This BIM feature encourages amicability among the team members which increases trust within the team.
ii	BIM implementation is done in a manner to map the project goals. This feature enhances mutual interest, shared vision and ideas of collaborative sharing for increasing the levels of trust within a project team members.
iii	BIM tools which provide convenient access to collaboration improve successful team interactions for increasing trust levels within the team.

8. Kindly explain the reasons for disagreement / any suggestions or recommendations

i. *The number of technical conflicts that can be identified by using BIM is only reduced in the construction phase. This statement does not become true for the design phase of a project where various technical issues arise due to requirement of high level of details. Therefore, in practice, amicable settlement of technical conflict can be expected in construction stage compared to initial stage of a BIM implemented project due to less conflicts.*

ii. *One of the main purposes of BIM implementation is to map the project goals. Therefore, obviously this feature is improved in BIM used project compared to the ordinary projects.*

iii. *Practically more interactions means more issues within team members. In general practice, this doesn't go smoothly. However, BIM promotes a higher level of logical conversations. Availability of information compared to the traditional practice provides more rational interactions which ultimately leads to increase trust within team members.*

Establishing effective problem solving mechanisms

Research findings reveled the following

Ref	BIM applicability for improving problem solving mechanisms
i	BIM platforms such as "Auto Desk- BIM 360 Team" facilitates convenient resource management of the project. This BIM feature encourages proper resource management to establish effective problem solving mechanisms.
ii	BIM implementation increases networking among the project team members. This feature promotes establishing effective problem solving mechanisms within the project.
iii	Being a pre-requisite of BIM implementation, corporative trainings are comparatively increased by BIM adoption which enables effective problem solving in a construction project.
iv	BIM provides a unified design model which improves team building. This feature simplifies establishing effective problem solving mechanisms.
v	Easy access to project information is a significant feature of BIM technology which facilitates improving acquisition of new knowledge, new information and creative ideas for the team members. This feature assists in establishing an effective problem solving mechanism.
vi	BIM implementation provides data capturing within the project model. This BIM feature enhances transparent communication which promotes effective problem solving among team members.
vii	BIM increases implementing a solid foundational strategy through its features to interpret the actual status of a project in a digital model. This significant BIM feature enables establishing an effective problem solving mechanism among the project team members.
viii	BIM has a unique ability to provide shared models of a project. This feature enhances effectiveness of communication and information exchange among team members which promotes establishing effective problem solving mechanisms.

9. Kindly explain the reasons for disagreement / any suggestions or recommendations

i. *Improved resource management is a must when using BIM in a project. There are various software introduced for achieving proper resource management in BIM implemented project.*

ii. *When practicing BIM level 2 standard in a project, it automatically establishes improved networks within project teams.*

iii. *As explained previously, having corporative training is not a unique feature of BIM implementation. Therefore, cannot fully agree on this statement.*

iv. *Improved team work is a feature that can be definitely expected from BIM implementation in a project. Further, following BIM standards reduces issues within a project team.*

v. *BIM adoption in a project requires to share information and details in different levels throughout the project. Easy access for information is a basic feature that can be expected from BIM implementation. So can agree for this statement.*

vi. *Data capturing can be easily done if project is implemented adhering to BIM standards. However, team members need to have required knowledge and expertise to do this successfully. This is automatically fulfilled within a well-established BIM team. Further, it is important to note that there should be restrictions while capturing data due to security reasons.*

vii. *This statement can be accepted as BIM is a improved way of establishing project strategies*

viii. *BIM implementation enables model sharing and it is obvious that it improves information sharing within project team.*

Encouraging intellectual disagreement

Research findings reveled the following.

Ref	BIM applicability for improving intellectual disagreement
i	BIM provides communication tools which increases group discussions among the project team to share information to establish effective communication. This feature encourages intellectual disagreement.
ii	Common platform provided for group discussion through BIM technology increases the probabilities for sharing viewpoints among team members for promoting intellectual disagreement.

10. Kindly explain the reasons for disagreement / any suggestions or recommendations

i. *Various communication tools are available in the construction industry and the selection of the appropriate method depends on the practice. It can be either e-mail or other chat modes such as 'whatsapp'. However, the setup is different from the traditional method and when it comes to BIM level 2 standard, an improved information sharing can be expected. Therefore, it can be said that BIM implementation improves effective communication.*

ii. *As explained above, BIM ability to provide effective communication also enables effective sharing of viewpoints among team members compared to the traditional method.*

11. Any other comments you would like to share about BIM

All improved features discussed above can only be expected in projects where BIM level 2 standard is adhered. Otherwise, they all automatically exist within the general traditional practice. Further, some of these improvements cannot be expected where there is a freshly established BIM team with less experience and knowledge.

I would like to thank you for the information given and time you have dedicated to this research. If you are interested to know the outcome of this research, it would be my pleasure to share it with you.

……

Final year postgraduate
Department of Building Economics
University of Moratuwa

Appendix G: Details of sources used for data collection

Ref. code	Data source
	Research Publications
RP1	Issa, R. (2016). Process and structure: Performance impacts on collaborative interdisciplinary team experiences. *Journal of Information Technology in Construction, 21*(2016). (177-187). Retrieved from https://www.itcon.org/papers/2016_12.content.08515.pdf
RP2	Vysotskiy, A., Makarov, S., Zolotova, J., & Tuchkevich, E. (2015). Features of BIM Implementation Using Autodesk Software. *Procedia Engineering, 117*(2015), 1143–1152. doi:10.1016/j.proeng.2015.08.248
RP3	Muñoz-La Rivera, F., Vielma, J. C., Herrera, R. F., & Carvallo, J. (2019). Methodology for Building Information Modeling (BIM) Implementation in Structural Engineering Companies (SECs). *Advances in Civil Engineering, 2019*, 1–16. doi:10.1155/2019/8452461
RP4	Papadonikolaki, E., Vrijhoef, R. & Wamelink, H. (2016). The interdependences of BIM and supply chain partnering: empirical explorations. *Architectural Engineering and Design Management, 12*(6), 476-494. doi:10.1080/17452007.2016.1212693
RP5	Haddad, Z. (n.a.). *Integrating BIM and LEAN for project delivery construction of a major hospital in Jordan.* Retrieved from http://leanconstruction.org/media/docs/2016-congress/Exhibitor%20Webinars/LCI-Prez-Zuhair-Haddad.pdf
RP6	Noor, S.N.A.M., Junaidi, S.R., & Ramly, M. K. A. (2018). Adoption of building information modelling (BIM): factors contributing and benefits. In *Proceeding of International Conference On Global Business and Social Sciences (ICGBSS 2018) 13 & 14 October 2018 The Everly Putrajaya Malaysia.* (pp.239-255). Retrieved from https://www.researchgate.net/publication/328737140_ADOPTION_OF_BUILDING_INFORMATION_MODELLING_BIM_FACTORS_CONTRIBUTION_AND_BENEFITS
RP7	Ma, Z., Mao, Na., & Yang, Q. (2016). A BIM based approach for quality supervision of construction projects, *Creative Construction Conference.*644-649. Retrieved from http://2016.creative-construction-conference.com/proceedings/CCC2016_100_Ma.pdf

Appendix G: Details of sources used for data collection

Ref. code	Data source
	Research Publications (Cont'd)
RP8	Ho, S. P. (2013). Enhancing knowledge sharing management using BIM technology in construction. T*he Scientific World Journal, 2013*. 1-10. Retrieved from https://www.researchgate.net/publication/261605383_Enhancing_Knowledge_Sharing_Management_Using_BIM_Technology_in_Construction
RP9	Nadeem, A., Wong, A. K. D., Akhanova, G., Azhar, S., & Wong, S. N. (2017). Application of Building Information Modeling (BIM) in Site Management—Material and Progress Control. In Proceedings of the 21st International Symposium on Advancement of Construction Management and Real Estate, 289–297. Retrieved from https://www.researchgate.net/publication/321268482_Application_of_Building_Information_Modeling_BIM_in_Site_Management_-_Material_and_Progress_Control
RP10	Malsane, S. & Sheth, A.Z. (2015). Simulate construction schedules using BIM 4D application to track progress. *International Journal of Mechanical And Production Engineering, 3*(6). 54-58. Retrieved from https://www.researchgate.net/publication/299738345_SIMULATE_CONSTRUCTION_SCHEDULES_USING_BIM_4D_APPLICATION_TO_TRACK_PROGRESS
RP11	Svalestuen, F, Knotten, Lædre, O., Drevland, F., & Lohne, J. (2017). Using building information model (BIM) devices to improve information flow and collaboration on construction sites. *Journal of Information Technology in Construction, 22*(2017). 204-219. Retrieved from https://www.itcon.org/papers/2017_11-ITcon-Svalestuen.pdf
RP12	Davies, K. McMeel, D. & Wilkinson, S. (2015). Soft skills requirements in a BIM project team. In *Proceedings of The 32nd CIB W78 Conference 2015, 27th-29th October 2015, Eindhoven, The Netherlands.* (pp.109-117). Retrieved from https://pdfs.semanticscholar.org/63c0/8f360f643681cfa57ec2238764206187e6d1.pdf
RP13	Holzer, D. (2016). *The BIM manager's handbook: guidance for professionals in architecture*. Retrieved from https://books.google.lk/books?id=JjLOCwAAQBAJ&pg=PA74&lpg=PA74&dq=bim+team+selection&source=bl&ots=UWwMt5L8E2&sig=ACfU3U3ld1fon6RjVBuMfN98XmpePBxtVw&hl=en&sa=X&ved=2ahUKEwi4x6Ldn5bkAhXKP48KHYf4BYIQ6AEwE3oECAcQAQ#v=onepage&q=bim%20team%20selection&f=false

Appendix G: Details of sources used for data collection

Ref. code	Data source
	Research Publications (Cont'd)
RP14	Silius-Miettinen, P. & Kähkönen, K. (2017). *Contractual and ownership aspect for BIM.* [Master's thesis, Tampere University of Technology]. Retrieved from https://www.researchgate.net/publication/320022021_CONTRACTUAL_AND_OWNERSHIP_ASPECTS_FOR_BIM
RP15	Khoshnava, S. M., Ahankoob, A., Preece, C., & Rostami, R. (2012). Potential application of BIM in construction dispute and conflict. In *Proceedings of Management in Construction Research Association (MiCRA) Postgraduate Conference.* (pp.178-184). Retrieved from https://www.researchgate.net/publication/268980388_Potential_Application_of_BIM_in_Construction_Dispute_and_Conflict
RP16	Shaikh, I. (2018). *Virtual team management in construction projects and the role of BIM.* [Master's thesis, Royal Institute of Technology Sweden]. Retrieved from http://www.diva-portal.org/smash/get/diva2:1252823/FULLTEXT01.pdf
RP17	Migilinskas, D., Pavlovskis, M., Urba, I. & Zigmund, V. (2017). Analysis of problems, consequences and solutions for BIM application in reconstruction projects. *Journal of Civil Engineering and Managemen, 23*(8). 1082-1090. Retrieved from https://www.researchgate.net/publication/321190190_Analysis_of_problems_consequences_and_solutions_for_BIM_application_in_reconstruction_projects
RP18	Mutis, I. & Hartmann, T. (Eds). (2019). Advances in informatics and computing in civil and construction engineering. In *Proceedings of The 35th CIB W78 2018 Conference: IT in Design, Construction, and Management. (*P. 686). Retrieved from https://books.google.lk/books?id=qalxDwAAQBAJ&pg=PA686&lpg=PA686&dq=bim+network+for+problem+solving&source=bl&ots=7j_gGe0LwN&sig=ACfU3U3pFSXdmaAfZpQ7mVUi-ZD2wwZ3PQ&hl=en&sa=X&ved=2ahUKEwjQz6iEj6LkAhV3_XMBHaAxCE44ChDoATAJegQICBAB#v=onepage&q=bim%20network%20for%20problem%20solving&f=false
RP19	Oraee, M., Hosseini, M. R., Papadonikolaki, E., Palliyaguru, R., & Arashpour, M. (2017). Collaboration in BIM-based construction networks: A bibliometric-qualitative literature review. *International Journal of Project Management, 35*(7), 1288–1301. doi:10.1016/j.ijproman.2017.07.001

Appendix G: Details of sources used for data collection

Ref. code	Data source
	Research Publications (Cont'd)
RP20	Ho, S., Tserng, H., & Jan, S. (2013). Enhancing knowledge sharing management using BIM technology in construction. Scientific World Journal. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3956413/
RP21	Garber, R. (2014). *BIM design: realising the creative potential of building information modelling*. Retrieved from https://www.wiley.com/en-us/BIM+Design%3A+Realising+the+Creative+Potential+of+Building+Information+Modelling-p-9781118719800
RP22	McGraw Hill Construction. (2009). *Smart market report.* Retrieved from http://images.autodesk.com/adsk/files/final_2009_bim_smartmarket_report.pdf
RP23	Fadakari, H. (2014). Evaluation of the application of building information modeling technology in intelligent architecture realization. *European Online Journal of Natural and Social Sciences, 3*(4). 634-646. Retrieved from file:///C:/Users/Piumi/Desktop/2764-7482-1-PB.pdf
RP24	Worden, K. (2016). *BIM and communication: implementation of building information modelling into an integrated project delivery contract to encourage project teams to communicate* [Master's thesis, California Polytechnic State University]. Retrieved from https://pdfs.semanticscholar.org/5811/d8eb6479a1ef2b6151c8abbe8f70daa10c07.pdf
RP25	Charehzehi, A., Chai, C., Md Yusof, A., Chong, H.-Y., & Loo, S. C. (2017). Building information modeling in construction conflict management. *International Journal of Engineering Business Management, 9.* 1-18 doi:10.1177/1847979017746257
RP26	Inguva, G. (2014). *Differences for employees who use BIM/VDC in the construction workplace* [Master's thesis, Colorado State University]. Retrieved from https://mountainscholar.org/bitstream/handle/10217/88558/INGUVA_colostate_0053N_12772.pdf?sequence=1
RP27	Laal, M. (2013). Positive interdependence in collaborative learning. *Procedia-Social and Behavioral Sciences*, *93*, 1433-1437. Retrieved from https://www.sciencedirect.com/science/article/pii/S1877042813035039

Appendix G: Details of sources used for data collection

Ref. code	Data source
	Research Publications (Cont'd)
RP28	Fry, R., Barrett, F., Seiling, J., & Whitney, D. (Eds.). (2002). *Appreciative inquiry and organizational transformation: Reports from the field*. USA: Greenwood Publishing Group Inc. Retrieved from https://books.google.lk/books?id=t5QHdmkJ7TYC&pg=PA53&lpg=PA53&dq=inquiring+needs+and+concerns+of+team+members&source=bl&ots=90WrF_z__Z&sig=ACfU3U1OwZgcgk2YiIXaYylZpa0DktbGCg&hl=en&sa=X&ved=2ahUKEwjFx-KP99TkAhXEuI8KHTkGCRIQ6AEwCXoECAcQAQ#v=onepage&q=inquiring%20needs%20and%20concerns%20of%20team%20members&f=false
	Online Forums
OF1	Dave, P. (2016, April 8). Looking for a BIM manager [Online forum comment]. Retrieved from https://www.revitforum.org/career-corner/29423-looking-bim-manager.html
OF2	Paavola, S. (2019). The secret life of design meetings [Online forum comment]. Retrieved from https://www.the-possible.com/impact-technology-bim-on-work-collaboration-team-behaviour/
	Websites
WS1	Autodesk Inc.. (2019). *About work sharing.* Retrieved from https://knowledge.autodesk.com/support/revit-products/learn-explore/caas/CloudHelp/cloudhelp/2018/ENU/Revit-Collaborate/files/GUID-0FC44807-DF06-4516-905A-4100281AC486-htm.html
WS2	Designing Buildings Ltd. (2019). *Collaborative practices for building design and construction. Retrieved from https://www.designingbuildings.co.uk/wiki/Collaborative_practices_for_building_design_and_construction*
WS3	George, H. (2012, January 01). *BIM collaboration and engineering - many heads are better than one.* Retrieved from https://www.thenbs.com/knowledge/bim-collaboration-and-engineering-many-heads-are-better-than-one
WS4	Wirz, A. (2018). Site supervision. *Digital Solutions*. Retrieved from https://www.digital.gruner.ch/en/blog/en-bauleitung-40

Appendix G: Details of sources used for data collection

Ref. code	Data source
	Websites (Cont'd)
WS5	Indeed. (2019). *BIM group leader.* Retrieved from https://www.indeed.com/viewjob?jk=18fc1e673368e25a&from=tp-serp&tk=1djvt9qmgfca5803
WS6	BIM Forum. (2019).*BIM uses.* Retrieved from https://bimforum.org/uses/
WS7	Chun Keung, N.G. (2017). *BIM agreement for design consultancy and sub-contract.* Retrieved from https://www.academia.edu/33201209/BIM_Agreement_for_Design_Consultancy_and_Sub-contract
WS8	Andre, G.R. (2011). *Building information modeling (BIM): Special contract issues.* Retrieved from http://www.klgates.com/building-information-modeling-bim--special-contract-issues-10-07-2011/
WS9	Correvate Ltd. (2019). *The ultimate guide to BIM in 2019*. Retrieved from https://vercator.com/ultimate-guide-to-bim/
WS10	Autodesk Inc. (2019). *BIM 360 docs - how to change a team member to a project admin.* Retrieved from https://knowledge.autodesk.com/support/bim-360-field/troubleshooting/caas/sfdcarticles/sfdcarticles/BIM-360-Docs-How-to-change-a-Team-Member-to-a-Project-Admin.html
WS11	BIM track. (2019). *What's BIM track?*. Retrieved from https://bimtrack.co/features
WS12	Advenser. (2019). *BIM corporate training.* Retrieved from https://www.advenser.com/bim-consulting-services/bim-training/
WS13	Balfour Beatty. (2019). *Integrating teams.* Retrieved from https://www.balfourbeatty.com/expertise/building-information-modelling-bim/integrating-teams/
WS14	Clavero, J. (2018, September 27). *Ways BIM management software improves communication to field operations.* Retrieved from https://esub.com/ways-bim-management-software-improves-communication-to-field-operations/
WS15	Autodesk Inc. (2019). *Discussions.* Retrieved from https://knowledge.autodesk.com/support/bim-360-team/learn-explore/caas/CloudHelp/cloudhelp/ENU/BIM-360Team/files/GUID-B31E7DBA-022C-4CE3-BAA8-24D035B9F83A-htm.html
WS16	Techture. (2019). *Training.* Retrieved from https://techture.global/training/

Appendix G: Details of sources used for data collection

Ref. code	Data source
	Websites (Cont'd)
WS17	Autodesk Inc. (2019). *BIM collaboration.* Retrieved from https://www.autodesk.com/autodesk-university/class/BIM-Collaboration-2012
WS18	Autodesk Inc. (2019). *Manage people in a project.* Retrieved from https://knowledge.autodesk.com/support/bim-360-team/learn-explore/caas/CloudHelp/cloudhelp/ENU/BIM-360Team/files/GUID-4EA1D64B-5F8D-472E-B5D7-7D98DCBCDB4A-htm.html
	Personal and company blogs
PCB1	Goubau, T. (2016, December 1). What is BIM? What are its benefits to the construction industry? [Web log post]. Retrieved from https://www.aproplan.com/blog/quality-management-plan-construction/what-is-bim-what-are-its-benefits-to-the-construction-industry
PCB2	David, B. (2018, May 22). 5 Important reasons to use building information modeling (BIM) [Web log post]. Retrieved from https://www.globalrealestateexperts.com/2018/05/5-important-reasons-to-use-building-information-modeling/
PCB3	Green, E. (2016, February 03). BIM 101: what is building information modeling? [Web log post]. Retrieved from https://www.engineering.com/BIM/ArticleID/11436/BIM-101-What-is-Building-Information-Modeling.aspx
PCB4	Sharma, A. (2016, July 6). Browser organisation for views – Part 03 [Web log post]. Retrieved fromhttps://thebimtheory.wordpress.com/tag/work-breakdown-structure/
PCB5	Ellis, G. (2018, September 25). 3 Essential steps to build a culture of transparency in construction [Web log post]. Retrieved from https://blog.plangrid.com/2018/09/3-essentials-steps-build-culture-transparency-construction/?doing_wp_cron=1566983374.2539548873901367187500
PCB6	Jackson, R. (n.a.). Client BIM briefing note: information management role *[Web log post]*. Retrieved from https://bimblog.bondbryan.co.uk/client-bim-briefing-note-information-management-role/

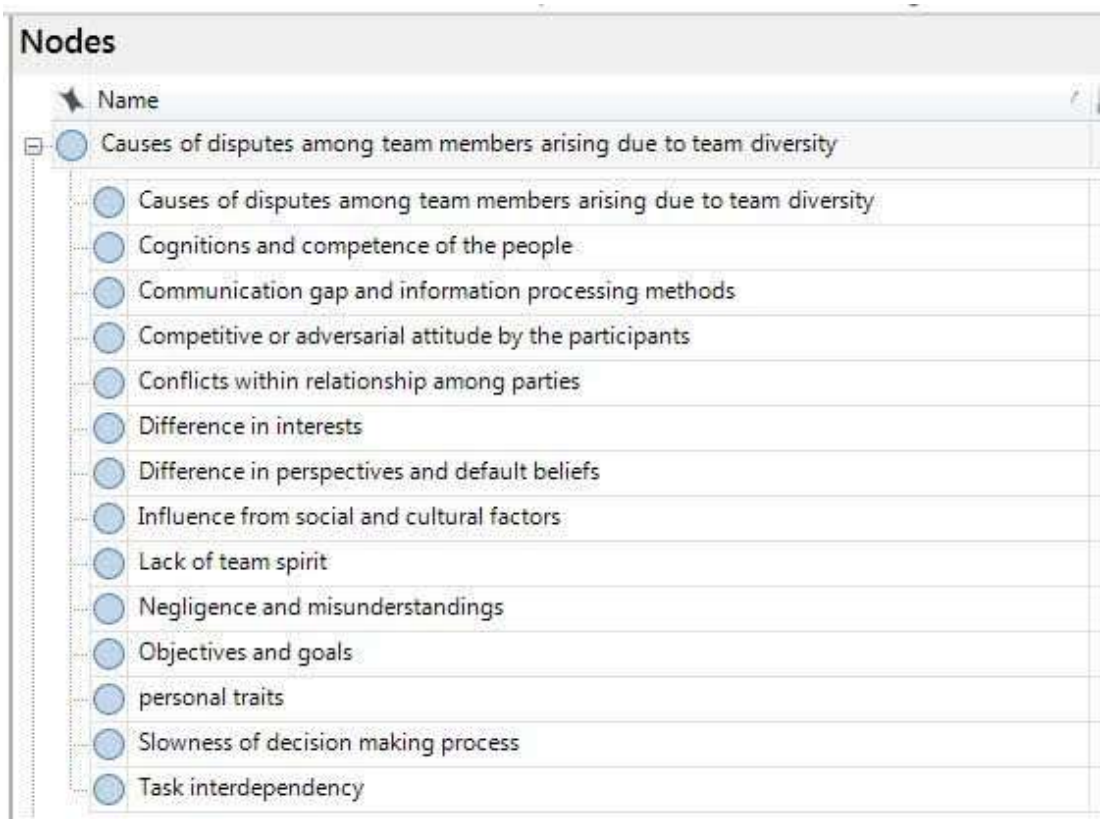
Appendix G: Details of sources used for data collection

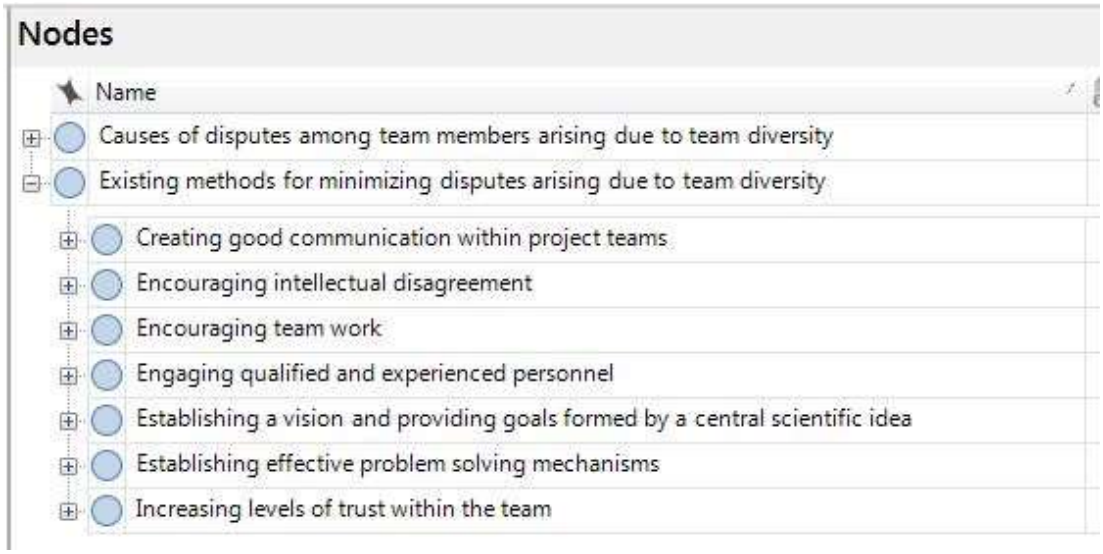
Ref. code	Data source
	Online discussions at professional networks
ODPN1	Somani, N. (2019, August 5). 5 Factors to save time and cost with BIM [Online forum comment]. Retrieved from https://www.linkedin.com/pulse/5-factors-save-time-cost-bim-neha-somani/
	Online newspapers and online magazines
ONM1	X3DMedia. (2019, July). LetsBuild looks to extend on-site BIM adoption. *AEC Magazine.* Retrieved from https://www.aecmag.com/software-mainmenu-32/1832-letsbuild-looks-to-extend-on-site-bim-adoption
ONM2	Morrical, Kate. (2014, October 29). Find the right members for your BIM team: 3 steps to help in the hiring process. *Redshift.* Retrieved from https://www.autodesk.com/redshift/find-the-right-members-for-your-bim-team/
ONM3	Edwards, B. (2015, February). Without trust and transparent communication BIM projects will fail. *The BIM Hub*. Retrieved from https://thebimhub.com/2015/02/09/without-trust-and-transparent-communication-bim-pr/#.XW-BnSgzbIV
ONM4	McCombe, V. (2018, March). *We need a standard approach to BIM and building contracts.* CIOB. Retrieved from http://www.bimplus.co.uk/people/we-need-standard-approach-bim-and-building-contrac/
ONM5	Dubie, D. (2002). Same software, different name?. *Network World, 19*(38). Retrieved from https://books.google.lk/books?id=VRgEAAAAMBAJ&pg=PT38&dq=many+of+the+new+software+used+in+BIM+offers+modelling+technology+that+lets+network+managers+group+the+network+devices,+application+and+web+servers,+and+databases+that+a+business+service+requires+as+one+managed+unit&hl=en&sa=X&ved=0ahUKEwjcp4LX7LbkAhXi4nMBHd0oDDgQ6AEIKDAA#v=onepage&q=many%20of%20the%20new%20software%20used%20in%20BIM%20offers%20modelling%20technology%20that%20lets%20network%20managers%20group%20the%20network%20devices%2C%20application%20and%20web%20servers%2C%20and%20databases%20that%20a%20business%20service%20requires%20as%20one%20managed%20unit&f=false

Appendix G: Details of sources used for data collection

Ref. code	Data source
	Online newspapers and online magazines (Cont'd)
ONM6	Sharif, T. (2016, December). The BIM process - A collaborative environment. *The BIM Hub*. Retrieved from https://thebimhub.com/2016/12/15/bim-process-collaborative-environment/#.XW92oSgzbIV
ONM7	Yalcinkaya, M & Singh, V. (2016, September). Data aggregation and information search in AEC/FM industry. *BIM Think space.* Retrieved from https://www.bimthinkspace.com/information-management/
ONM8	Gilson, R. (2018, June). Maximizing project delivery through BIM coordination and integration. *Consulting Specifying Engineer*. Retrieved from https://www.csemag.com/articles/maximizing-project-delivery-through-bim-coordination-and-integration/
ONM9	Krieger, J. (2013, May 30). 5 tips for running a successful BIM coordination meeting. Building Design & Construction. Retrieved from https://www.bdcnetwork.com/5-tips-running-successful-bim-coordination-meeting
	BIM guidelines and BIM policies
GP1	U.S. Department of Veterans Affairs. (2010). *BIM roles and responsibilities.* Retrieved from https://www.cfm.va.gov/til/bim/BIMGuide/roles.htm
GP2	Building and Construction Authority of Singapore. (August, 2013). BIM essential guide for BIM adoption in an organization. Retrieved from http://bimsg.org/wp-content/uploads/2013/08/essential-guide-adoption.pdf
GP3	Veelaert, I. (n.a.). *Best practices for using BIM 360 team and collaboration for revit.* Retrieved from https://cdn2.hubspot.net/hubfs/2510442/Autodesk_Collaboration_For_Revit_Best_Practices_eGuide.pdf#targetText=Because%20Collaboration%20for%20Revit%20stores,even%20search%20within%20the%20model.

Appendix H: NVivo coding structure used for data collection and analysis





Appendix H: NVivo coding structure used for data collection and analysis

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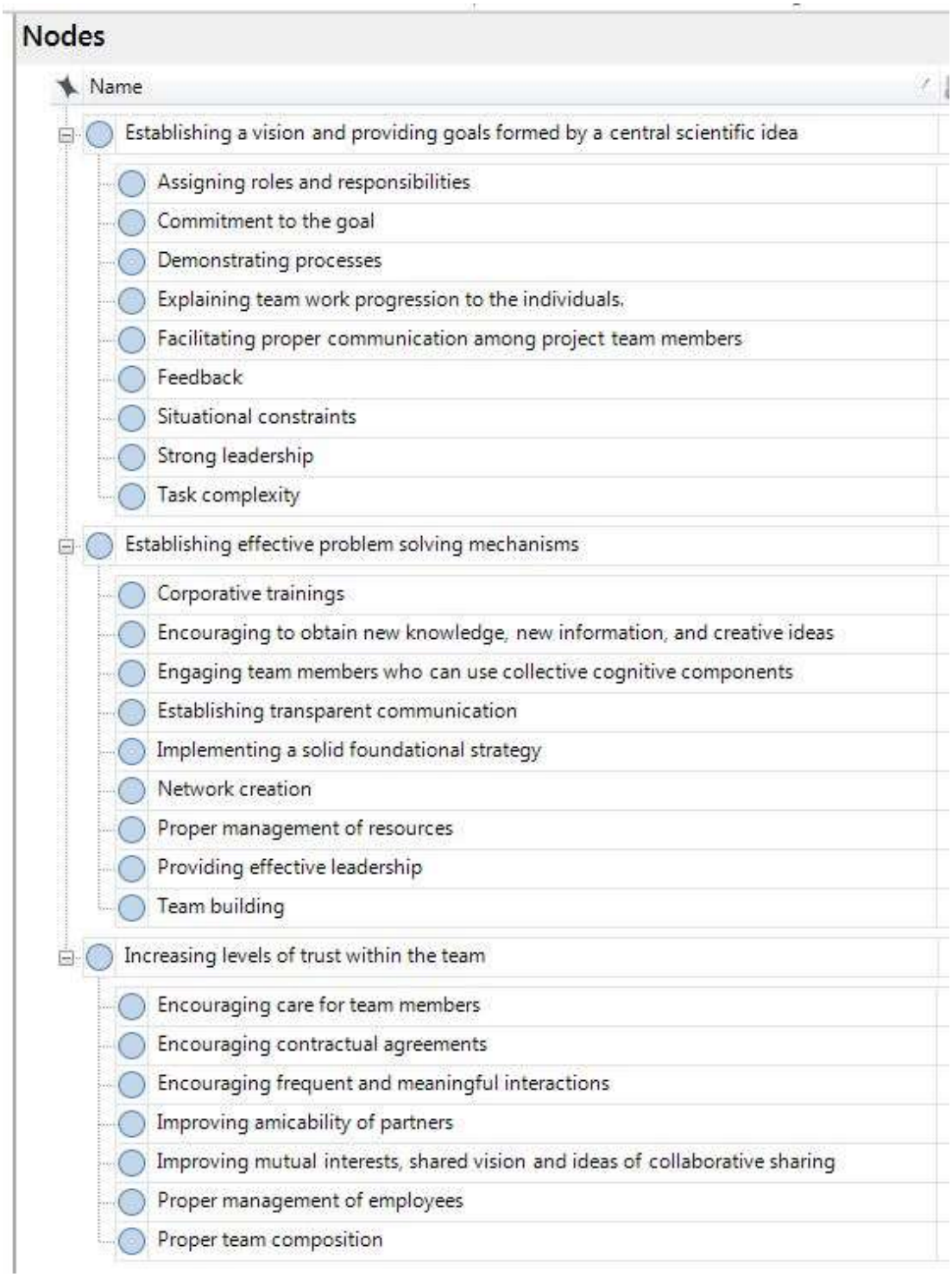

Appendix I: Summary of research finding and analysis

Table I.1: Summary of research finding and analysis

Minimization method	IS	Technique for implementation	Applicability of BIM for improvement
Encouraging team work	t.1	Providing cooperative working environments	Applicable
	t.2	Providing positive interdependent team environment	Applicable
	t.3	Assigning specific responsibilities	Applicable
	t.4	Inquiring concerns and needs of team members	Likely applicable
	t.5	Valuing team members' contribution	Likely applicable
	t.6	Supervision	Applicable
Establishing a vision and proving goals formed by a central scientific idea	t.7	Feedback	Applicable
	t.8	Commitment to the goal	Likely applicable
	t.9	Task complexity	Likely applicable
	t.10	Situational constraints	Likely applicable
	t.11	Assigning roles and responsibilities	Applicable
	t.12	Demonstrating processes	Applicable
	t.13	Explaining team work progression to the individuals.	Applicable
	t.14	Facilitating proper communication among project team members	Applicable
	t.15	Strong leadership	Likely applicable
Creating good communication within project teams	t.16	Increasing strength of personal contacts.	Not applicable
	t.17	Holding meetings	Likely applicable
	t.18	Establishing communication networks	Applicable
	t.19	Providing leadership	Likely applicable
	t.20	Providing training, developing and support for improving communication	Applicable
Engaging qualified and experienced personnel	t.21	Holding interviews	Likely applicable
	t.22	Using group decision approach	Likely applicable
	t.23	Using psychometric tests	Likely applicable
	t.24	Using multi-criteria decision aid methods	Likely applicable
Increasing levels of trust within the team	t.25	Improving amicability of partners	Applicable
	t.26	Encouraging contractual agreements	Likely applicable
	t.27	Improving mutual interests, shared vision and ideas of collaborative sharing	Applicable
	t.28	Encouraging care for team members	Not applicable
	t.29	Proper management of employees	Likely applicable
	t.30	Proper team composition	Likely applicable
	t.31	Encouraging frequent and meaningful interactions	Applicable

Appendix I: Summary of research finding and analysis

Table I.1: Summary of research finding and analysis (Cont'd)

Minimization method	IS	Technique for implementation	Applicability of BIM for improvement
Establishing effective problem solving mechanisms	t.32	Proper management of resources	Applicable
	t.33	Network creation	Applicable
	t.34	Corporative trainings	Applicable
	t.35	Team building	Applicable
	t.36	Providing effective leadership	Likely applicable
	t.37	Engaging team members who can use collective cognitive components	Applicable
	t.38	Encouraging to obtain new knowledge, new information, and creative ideas	Likely applicable
	t.39	Establishing transparent communication	Applicable
	t.40	Implementing a solid foundational strategy	Applicable
Encouraging intellectual disagreement	t.41	Establishing effective communication	Applicable
	t.42	Understanding personalities of other team members	Likely applicable
	t.43	Encouraging listening	Likely applicable
	t.44	Sharing viewpoints	Applicable

Appendix J: Summary of interview outcome

Table J.1 Summary of interview outcome

Inquiry	Overall response of Interviewee				
	EX1	EX2	EX3	EX4	EX5
Encouraging team work					
BIM provides a common platform which facilitates simultaneous working ability. This BIM feature enables an extensive corporative working environment to the team members to encourage team work.	Agree	Agree	Agree	Agree	Agree
BIM feature which facilitates collaboration of works enhances positive interdependent team environment that promotes team work.	Agree	Agree	Agree	Agree	Agree
Construction project teams which involves members in different disciplines can be benefited by BIM technology as assigning specific responsibilities becomes a feature that can be undeniably expected while implementing BIM technology in a project. This feature assists in improving team work capabilities of the team members.	Agree	Agree	Agree	Agree	Agree
Information sharing and collaborative work environment which is provided by BIM implementation contributes for providing supervision of team members to encourage team work.	Agree	Agree	Agree	Agree	Agree
Establishing a vision and providing goals formed by a central scientific idea					
BIM ability to simulate actual progress of the site in a shareable digital model can improve feedback process on executed work. This feature can assist in maintaining the project direction towards its ultimate goal.	Agree	Agree	Agree	Agree	Agree
Assigning relevant roles and responsibilities to the members of a project team which provides a substantial foundation to sustain project goals is identified as a pre-requisite for implementing BIM technology in a project.	Agree	Agree	Agree	Agree	Agree
Establishing the manner of project execution is a pre-requisite for implementing BIM. This BIM feature enhances demonstrating processes within the project which ensures the goals are established through a central scientific idea.	Agree	Agree	Agree	Agree	Agree
BIM simulates the actual events of the project. This feature improves the ability of explaining team work progression to the individuals to establish goals within the project.	Agree	Agree	Agree	Agree	Agree

Appendix J: Summary of interview outcome

Table J.1 Summary of interview outcome (Cont'd)

Inquiry	Overall response of Interviewee				
	EX1	EX2	EX3	EX4	EX5
Establishing a vision and providing goals formed by a central scientific idea (Cont'd)					
BIM provides a good medium of communication among team members through a shared platform. Therefore, BIM technology improves communication among project team members which ensures establishing common goals within the project.	Agree	Agree	Agree	Agree	Agree
Creating good communication within project teams					
The ability for exchanging a virtual information model with real time data among the team members assures that BIM technology can drive a project team to establish a better communication network.	Agree	Agree	Agree	Agree	Agree
Training is an essential pre-requisite for BIM implementation. This requirement directs team members to improve communication within the team.	Agree	Disagree	Partially agree	Agree	Partially agree
Increasing levels of trust within the team					
Automated models created by BIM technology facilitates minimizing technical conflicts of the projects. This BIM feature encourages amicability among the team members which increases trust within the team.	Agree	Agree	Agree	Agree	Agree
BIM implementation is done in a manner to map the project goals. This feature enhances mutual interest, shared vision and ideas of collaborative sharing for increasing the levels of trust within a project team members.	Agree	Agree	Agree	Agree	Agree
BIM tools which provide convenient access to collaboration improve successful team interactions for increasing trust levels within the team.	Agree	Agree	Agree	Agree	Agree
Establishing effective problem solving mechanisms					
BIM platforms such as "Auto Desk- BIM 360 Team" facilitates convenient resource management of the project. This BIM feature encourages proper resource management to establish effective problem solving mechanisms.	Agree	Agree	Agree	Agree	Agree

Appendix J: Summary of interview outcome

Table J.1 Summary of interview outcome (Cont'd)

Inquiry	Overall response of Interviewee				
	EX1	EX2	EX3	EX4	EX5
Establishing effective problem solving mechanisms (Cont'd)					
BIM implementation increases networking among the project team members. This feature promotes establishing effective problem solving mechanisms within the project.	Agree	Agree	Agree	Agree	Agree
Being a pre-requisite of BIM implementation, corporative trainings are comparatively increased by BIM adoption which enables effective problem solving in a construction project.	Agree	Agree	Agree	Agree	Partially agree
BIM provides a unified design model which improves team building. This feature simplifies establishing effective problem solving mechanisms.	Agree	Agree	Agree	Agree	Agree
Easy access to project information is a significant feature of BIM technology which facilitates improving acquisition of new knowledge, new information and creative ideas for the team members. This feature assists in establishing an effective problem solving mechanism.	Partially agree	Agree	Agree	Agree	Agree
BIM implementation provides data capturing within the project model. This BIM feature enhances transparent communication which promotes effective problem solving among team members.	Agree	Agree	Agree	Agree	Agree
BIM increases implementing a solid foundational strategy through its features to interpret the actual status of a project in a digital model. This significant BIM feature enables establishing an effective problem solving mechanism among the project team members.	Agree	Agree	Agree	Agree	Agree
Being a pre-requisite of BIM implementation, corporative trainings are comparatively increased by BIM adoption which enables effective problem solving in a construction project.	Agree	Agree	Agree	Agree	Partially agree
BIM has a unique ability to provide shared models of a project. This feature enhances effectiveness of communication and information exchange among team members which promotes establishing effective problem solving mechanisms.	Agree	Agree	Agree	Agree	Agree

Appendix J: Summary of interview outcome

Table J.1 Summary of interview outcome (Cont'd)

Inquiry	Overall response of Interviewee				
	EX1	EX2	EX3	EX4	EX5
Encouraging intellectual disagreement					
BIM provides communication tools which increases group discussions among the project team to share information and provides high access to information to establish effective communication. This feature encourages intellectual disagreement.	Agree	Agree	Agree	Agree	Agree
Common platform provided for group discussion through BIM technology increases the probabilities for sharing viewpoints among team members for promoting intellectual disagreement.	Agree	Agree	Agree	Agree	Agree

Appendix K: Cognitive map of the literature findings