Project Communication

Enhancing the communication practices of a design team for achieving project success

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BILFINGER

Master Thesis

Project Communication

Enhancing the communication practices of a design team to achieve project success

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Preface

I started this thesis as a novice researcher and had no experience in writing even a single research paper as a student. But, now at the end of this thesis I can confidently say that I have not only grown as a researcher but also as a student ready to make the transition into a professional civil engineer.

The topic I have selected for the research is a topic that I feel plays the most vital role in any project. The reason for this I believe is that, from the start of any given activity in a project until its finish, individuals in the project need to communicate. From my perspective, communication in a project is a continuous process, that connects the various individuals working on the project with each other, and thus communication becomes vital in managing people in projects. Thus, this belief and the curiosity to know more about how to manage people in projects through communication had been the driving force in my journey as a student to a researcher during this thesis.

Here at first, I would like to thank Niels for giving me an opportunity to work on this topic, sharing his experience and insights as a project manager, and explaining to me the true potential of the words *'Why, How & What'*. Second, I would like to show my gratitude towards Bauke and Erik, for being there for me every week, guiding me in every step and decision I took regarding my research during these last eight months. Third, I would like to thank Hans for all the detailed handwritten comments and feedback he provided on my thesis, which has helped me stay focused on my research topic and improve its overall quality.

The last few months have certainly changed me as a person, and it is a change that is hard for me to pen down. Thus, I would like to thank my family and friends, who have supported me with not only this thesis but other fronts of life too.

To the readers of this report, I hope you all like reading it and in the end, you can have some takeaways on how you can bring a change in the way you communicate with your project team.

Vrajesh Ved

Delft, August 2021

Executive summary

Why?

The first question that arises when reading this report is, why is research on project communication required?

Researchers over the past few years have shown that communication is an integral factor in delivering successful results in the design phase of a project. This is said so as there are multiple professionals from diverse backgrounds who come together to prepare the design of a project. Consequently, communication between these professionals becomes a key component since it is the way through which these professionals share project information apart from sharing their knowledge and thoughts during this stage.

However, it is seen that the relationship between communication and project success is not well defined, in particular, the understanding of the barrier and drivers of communication in a design team seems to be obscure. Thus, this research work builds on this theme and tries to understand project communication in detail. By examining the communication practices of a design team through the lens of literature, this study aims to describe how communication affects the project outcome and specify ways to improve it. To fulfil this objective, this research tries to answer the following question:

"How can improving the communication practice of a design team help it to achieve project success?"

How?

The next question is, how was this research conducted to fulfil the research objective and get an answer to the main question?

To answer this question the research was divided into three parts. In part A, the literature was reviewed to gain insights and reflect on the attributes that describe the communication of a design team and explain the influence of these attributes on project success. This step helped to develop a theoretical model describing how communication should be practised in a design team for achieving project success, and provide topics based on which further investigation could be carried out.

In part B, a document review was done to analyse the documents produced by a design team which provide guidelines for the communication practices the members working in the team need to follow. This document review was undertaken to understand how using these documents a design team wants to define the team's communication practices for achieving project success.

In part C, semi-structured interviews were used to obtain empirical data explaining the communication practices followed by the team while working on a project. This step helped to develop a model which depicted the relationship between project success and the communication practices followed by a team.

Following this, findings obtained from part C were compared with the theoretical model developed in part A. The objective of this comparison was to analyse and modify the model to depict the changes with which communication practices were adapted in practice to enhance their effectiveness and represent the communication practices that serve as barriers to achieving successful results. Furthermore, based on the results of these comparisons, a comparison of the communication practices described in the documents reviewed in part B was made. Through this comparison, the gap in the guidelines provided in these documents concerning the communication practices for the use of the team was identified.

What?

The last question is, what are the results of this research and what do they signify?

The results of this research indicate that communication is the central aspect that controls the functioning of the team. Communication practices were found to impact the collaboration, coordination, project performance of the team, and the quality of the work produced by the team. The impact of communication practices on these aspects of a project was categorised under two categories, drivers, and barriers of communication.

The drivers of communication like *feedback, multidisciplinary interaction, social interaction, stand-up meetings, and increased frequency of communication*, were found to have a positive impact on the aspects of the project mentioned above and enhance the performance of the team on those aspects. Similarly, the barriers of communication like *reduced face-to-face communication, build-up of participants in a meeting, large group size, high frequency of emails, and high frequency of meetings*, were found to limit the performance of the team.

These results helped to recognize the scope of improvement in communication practices and recognize the gap in the theoretical model developed. Following this, recommendations for improving the communication practices and mitigating the barriers to project success were made and validated with experts.

Additionally, these recommendations were categorized using two parameters; impact, and the time required to implement the recommendation. The objective of making this categorisation was to enable the team to focus on recommendations that would yield immediate results and highlight the recommendations which would help the team to improve in the long run. The categorisation of these recommendations is described in **Figure 1**.

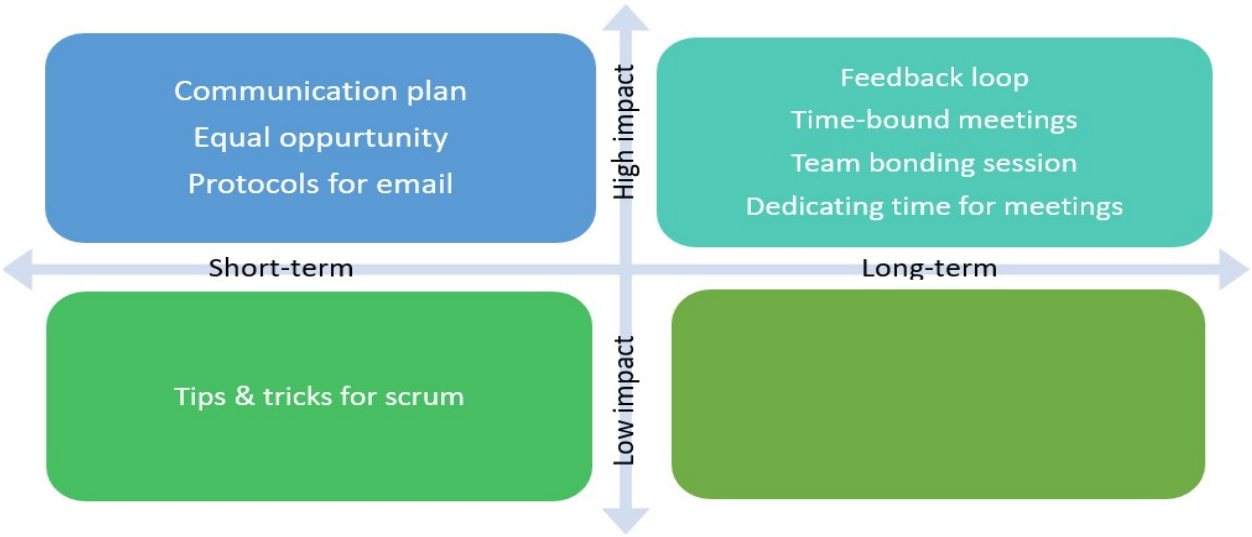

Figure 1: Categorisation of recommendations

Nevertheless, this research had some limitations. This research was conducted to examine the relationship between project success and communication practices of a team. Thus, the results of this research and the recommendations do not cover the communication the team has with other stakeholders of the project like the client and the vendors. Also, these results may not be directly applicable when multiple companies are involved in developing a design of a project, as in the case of a joint venture project.

For future research, the methodology adopted, and the attributes of communication defined in this research for investigating the relationship between communication and project success can be used as a template to find drivers and barriers of communication in a team during the construction phase of a project. Similarly, this work can be expanded to encompass drivers and barriers of communication between stakeholders of a project.

An interesting observation made during this research was that 3D modelling software (BIM) can be used as a communication medium in the team. So, future researchers can also focus on research investigating if BIM is a better medium to discuss a design with a non-technical person compared to 2D drawings and images.

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1. Introduction

Why?

This chapter is written to explain the title of this thesis and explain the need to address this topic.

What?

Through this chapter, the role of team communication as a key project success factor is described, and an introduction to the company taking part in this study is given.

How?

By framing a problem statement that describes the need to understand the role of communication in the work of a team to succeed in the design phase of a project.

1.1 Background

Over the years scholars have reiterated that the criteria set up for considering the design of a construction project to be successful are based on the iron triangle of project management. That is if a project is delivered within schedule, under the planned finances, and according to requirements, it is considered a success (Nguyen, Ogunlana, & Lan, 2004). However, this measure of success of a project is simplistic, because it overlooks important soft results of a project like satisfaction of end user and satisfaction of the team developing the project (Scott-Young & Samson, 2008). The research of Scott-Young et al. (2008), further states that project success for a team can be measured using other aspects such as long-term business success, learning that prepares the organization for the future, and development of individuals.

Nevertheless, several scholars in their work have articulated factors that contribute towards a design team achieving project success. Chan et al. (2004), found forty-four factors which effected project success and categorised them under five categories; Project-related factors, Project management-related factors, Human-related factor, External factors, and Procurement-related factors. While the category of Human factors accounted for the technical skills and experience of the client and the design team, the category of Project management encompassed factors such as communication, planning and control mechanisms.

Similarly, Nguyen et al. (2004), showed twenty factors important for managing the design of large construction projects. This list included factors such as support of management, well-defined scope, thorough contract, and communication. Jha & Iyer (2006), found fourteen factors influencing the project performance of design teams. These factors were further classified into two categories, success factors and failure factors. The few factors placed in the category of success factors were checking and feedback, direct and informal communication channels, and understanding the operational difficulties of the client.

Although the success of a project is dependent on many factors, the factor of communication remains integral in delivering a successful project (Kamalirad, Kermanshachi, Shane, & Anderson, 2017). Communication is acknowledged as a critical success factor in the design phase of a project since there are several individuals with different expertise involved in creating a comprehensive design for a project (Kamalirad, Kermanshachi, Shane, & Anderson, 2017). Chan et al. (2004) described that communication serves as the critical connection between individuals working in these projects since through communication individuals can share their ideas and information which is needed by all the members concerned with the project.

The research of Otter et al. (2008), also expressed that effective communication is needed for collaboration of the team developing a design for a project. Since the aspects that are important to the smooth functioning of the team, such as the relationship between the individuals, trust, constructive dialogues, and resolution of conflicts are dependent on the participants' ability to communicate openly and efficiently (Otter & Emmitt, 2008).

As communication is regarded as a crucial factor for project success, communication management is thus viewed as an essential strategy by organizations for achieving project success (Mavuso & Agumba, 2016). Although scholars and practitioners believe that communication in a design team is crucial for project success, the literature describing this relationship is limited (Safapour, Kermanshachi, Kamalirad, & Tran, 2019). Moreover, the research of Scott-Young et al. (2008), shows that people management factors influence project success more than technical factors, and yet they conclude that empirically based research on the soft side of project management is scarce.

Given that communication is one of the key factors for achieving project success, the relationship between communication and project success must be set up comprehensively. By understanding the barrier and drivers of communication in a design team, the probability of achieving project success can be improved. This research work builds on this theme and tries to understand project communication in detail. By examining the communication practices of a design team through the lens of literature, this study aims to describe how communication affects the project outcome and specify how to improve it.

1.2 Company Introduction

Bilfinger Tebodin is a design and engineering company that offers many services to their clients concerning construction project management of industrial plants. The industries covered under these services are petrochemical, oil & gas, food & beverages and pharmaceutical, to name a few. The company offers full-scale project services from (feasibility) studies to basic engineering, detailed engineering and EPC(m). The company understands the client’s need and designs a project that generates value for the client in the form of a smooth production line, low cost of operations, and maximum reliability.

For designing these industrial projects, the company has professional engineers having expertise in various disciplines such as civil, mechanical, electrical, instrumentation and piping. Apart from these disciplines, professionals are working in non-technical roles in this design team. These professionals aid in the functioning of the team and have contact with external stakeholders. These professionals are the project managers, contract managers, procurement team, IT team, etc.

Until now, the company is mainly developing designs for industrial projects with a tender value of several million euros as well as portfolios of smaller projects for several clients. So, the size of the team needed to develop the design was limited to twenty to thirty members. However, every year they also provide their service for developing designs for large-scale multimillion industrial projects. To meet this goal, the company has to increase the team size to sixty members or more. Thus, the company is facing a conundrum that, whether the communication practices followed by the team so far, needs changes when working on large-scale projects to achieve successful results for the project or not.

Although the company works on both brownfield and greenfield projects, maintenance and plant overhaul projects, this study only considers greenfield projects as these are the projects being developed by the company during the period of study. Currently, the company uses a waterfall management approach and is trying to adopt certain elements of the agile management approach like project boards, and stand-up meetings, for managing their projects and the communication channels within the project.

1.3 Problem statement

The discussion concerning project communication presented in the above sections is summarized in the form of the problem statement framed for this research.

The two sub-sections above introduced the role of communication in the working of a team during the design stage of a project. The main point highlighted was that project success is dependent on many factors. But having effective communication within a design team is key to achieving good project results. Communication not only serves as the critical connection between individuals working in these projects by allowing them to share their ideas and information. It also influences aspects such as relations, trust, and team building. Thus, the following problem statement is defined for this research work:

"From earlier research, it is known that communication plays a vital role in the project. Communication between design team members is said to have a bearing on the team performance and their chances of meeting the project success criteria. However, little research has been done that describes the relationship between project communication and project success. Especially, describing the factors which drive the communication in the design team and the factors which act as communication barriers to achieving project success."

1.4 Structure of the report

The graduation thesis presents a study aimed at further contributing to understanding the relationship between project communication and project success by defining the drivers and barriers to communication of a design team. This report has been divided into three distinct parts with each part consisting of a few chapters that present different concepts and steps performed as a part of this research. **Figure 2** illustrates these chapters.

There are three chapters in part A. **Chapter 1,** gives a general introduction to the topic and shows the need to study it. In **Chapter 2**, the research questions are formulated and the method adopted to find an answer to these is also described. **Chapter 3** is a literature review, that outlines the currently offered scientific literature on the various attributes describing project communication. Besides the association of these attributes with project success is also explained in detail.

Part B consists of three chapters. **Chapter 4,** is a desk review to explain the communication procedure a design team has. **Chapter 5,** relates to giving insights on the communication practices of a design team using semi-structured interviews. In **Chapter 6,** the results obtained from the semi-structured interviews are explained and analysed.

Part C includes three chapters. In **Chapter 7,** the empirical findings obtained from the interviews are compared with the communication practices described in theory, and an analysis is made. **Chapter 8** is a discussion on the results, and recommendations to convert these results for practical use. Finally, the report concludes with **Chapter 9**, where the conclusions, limitations of this research and recommendations for future research are described.

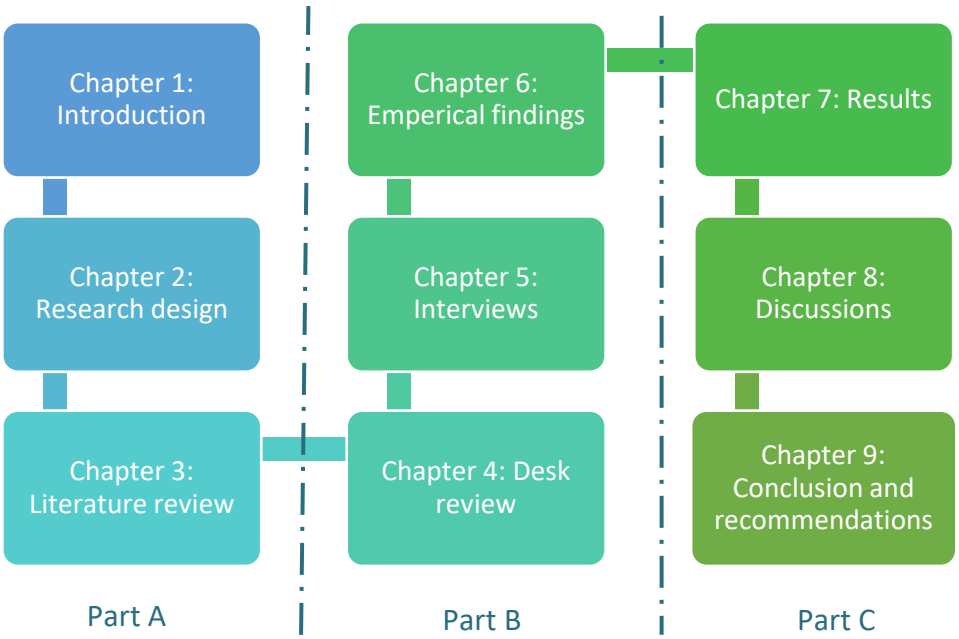

Figure 2: Structure of the report

2. Research Design

Why?

This chapter defines the main purpose of this research and sets the boundary conditions for it.

What?

Through this chapter, the relevance of this study from an academic and practical point of view, and the process followed to achieve the result of this research is explained.

How?

By framing a research question that helps address the problem and describing the method used to find the answer.

2.1 Research objective

The aim of this research is split into three parts. First, using the literature, the attributes of project communication are defined to understand how communication works in a project team. Following it, the relation between these attributes and the project outcome is investigated. The second part relates to understanding the communication practices of a design team through document scanning and semi-structured interviews. The third is to compare these findings to find the differences arising between them and suggest recommendations for improving these practices and procedures for helping a design team to achieve project success.

2.2 Relevance

Academic

This research contributes to the literature by supplying empirical data on project communication of a team working in the design stage of a construction project. The existing literature supplies details of various attributes used to describe the communication of the design team, and it also describes communication as a key factor in achieving project success. Using the empirical data, the link between these two topics would be proved. This would help to have a better grasp on the topic of team communication in the design stage, thus leading to more insights into how project communication can be improved to achieve project success.

Practical notion

Through this research, the aim is also to contribute to supplying a comprehensive insight into how communication works within the existing design team of the company. Through this study, the drivers, and barriers to communication as experienced by the individuals working in the team will be highlighted. Based on this empirical evidence and insights obtained from literature,

suggestions can be provided that help to improve the communication practices followed by the company for their projects. These suggestions can also help the company to alter the communication practices based on the scale of the projects undertaken.

2.3 Research questions

Based on the description of the context of the research, the aim of the research and the problem statement defined, the following main research question is framed:

"How can improving the communication practice of a design team help it to achieve project success?"

Sub questions:

1. How does communication relate to project success?

2. What defines how a team communicates?

3. What are the barriers and drivers of communication?

Through the first sub-question, the aim is to reflect on the attributes that describe the communication of a design team and explain the influence of these attributes on project success. Answering this sub-question helps to develop a theoretical model based on literature, describing how communication should be practised in a design team.

The second sub-question is used to describe the actual communication practices of a design team. The description of this practice is provided by a twofold investigation. The first step describes the procedures that guide the communication practices of a design team. These procedures are explained in documents used by a design team. A document review will be conducted to investigate them. The second step is to interview the different individuals working inside a design team. The empirical data obtained through such interviews help in developing an understanding of how these procedures are used in practice. Through these two steps, a model describing the actual communication practices of a design team is developed.

The third sub-question is employed to compare the results obtained through the first two sub-questions. Using the theoretical model, the practices which help a design team achieve project success are highlighted, and the gap between the actual practice and the practices prescribed by the theoretical model is discussed.

By following the various steps to receive answers for the three sub-questions, the answer to the main question will be provided. Further, the recommendations made for improving the communication practices of a design team will be confirmed by having interviews with two members of the design team.

2.4 Research scope

The scope of this research is confined to studying the communication practices of a design team developing a design for an industrial project. An industrial project is a project where production lines are used to convert raw materials into usable products. Moreover, the design phase is defined as the phase of the project where the functional requirements of a project given by a client are converted into detailed drawings and models, which can be used to build the project. Further, this research work focuses on examining the communication practices adopted by a design team for their internal communication. Since the client and vendors are not involved in the daily internal communication of the design team, they do not form a part of this design team.

2.5 Methodology

A research method is used to find, process, and analyse the data for the research. Three primary methodologies used in this research are literature review, document review and semi-structured interviews. The usage of these three methods in the context of this research is discussed below.

Literature review

The literature review technique offers research papers from journals and conferences, reports, books, and other publications on the selected subjects. The literature review is initially used in this study for finding an answer to the first sub-question, i.e., SQ 1. First, the literature review helps in exploring the concepts and theories that define the attributes used to describe communication in a design team. Further, the literature is scanned to find how these attributes influence project success. The attributes of communication and their relationship with project success are represented in the form of a theoretical model. This model is then used later in this research to assess and compare the actual communication practices of a design team. A detailed procedure for conducting a literature review is described in **Appendix A: Procedure for literature review**.

Document review

Document review is a qualitative research method through which a researcher scans and evaluates the different documents concerning the topics of research. In this research, the documents produced by the company to be used by a design team, describing the procedures the team members must follow while communicating with each other, are examined. The investigation of the project documents stating the requirements and the aims the project should meet as given by the client also serves as a source of data. In this process, a partial understanding of how a design team communicates is obtained.

Semi-structured interview

The semi-structured interviews are used to obtain empirical data from the design team. The topics related to team communication found through the literature review are used to construct questions for the interview. Through the interview, the aim is to collect data on how the professionals view the communication practices within their team.

The use of semi-structured interviews allows a researcher to find out what are key factors related to team communication that affect the project results by mixing open and closed questions. Another purpose of using semi-structured interviews for this research is that these interviews are conducted on an individual level. Therefore, bias created in the answers of the interviewee due to the presence of other individuals from the team can be eliminated. Further, using this data from the semi-structured interviews, and the document review, an answer to the second sub-question, SQ 2, is provided.

The next step in this research is to then compare the findings received from the literature review, document review and semi-structured interview. This comparison of actual communication practices of a design team with the theoretical model on team communication helps to find the areas for improving communication practices and answer the third sub-question, SQ 3.

Through the final discussion on these comparisons, recommendations for communication practices are developed and shared with two different individuals working in a design team. This procedure helps confirm the recommendations and provides an understanding of their applicability in practice.

To conclude this study, answers to all sub-questions and an answer to the main research question are presented. The implications of these answers in terms of an academic and practical perspective are also discussed along with some final comments, suggestions for future research and limitations of the study. **Figure 3** below summarises the research method through a flow chart and aids the readers of this research by providing a brief overview of the entire research process.

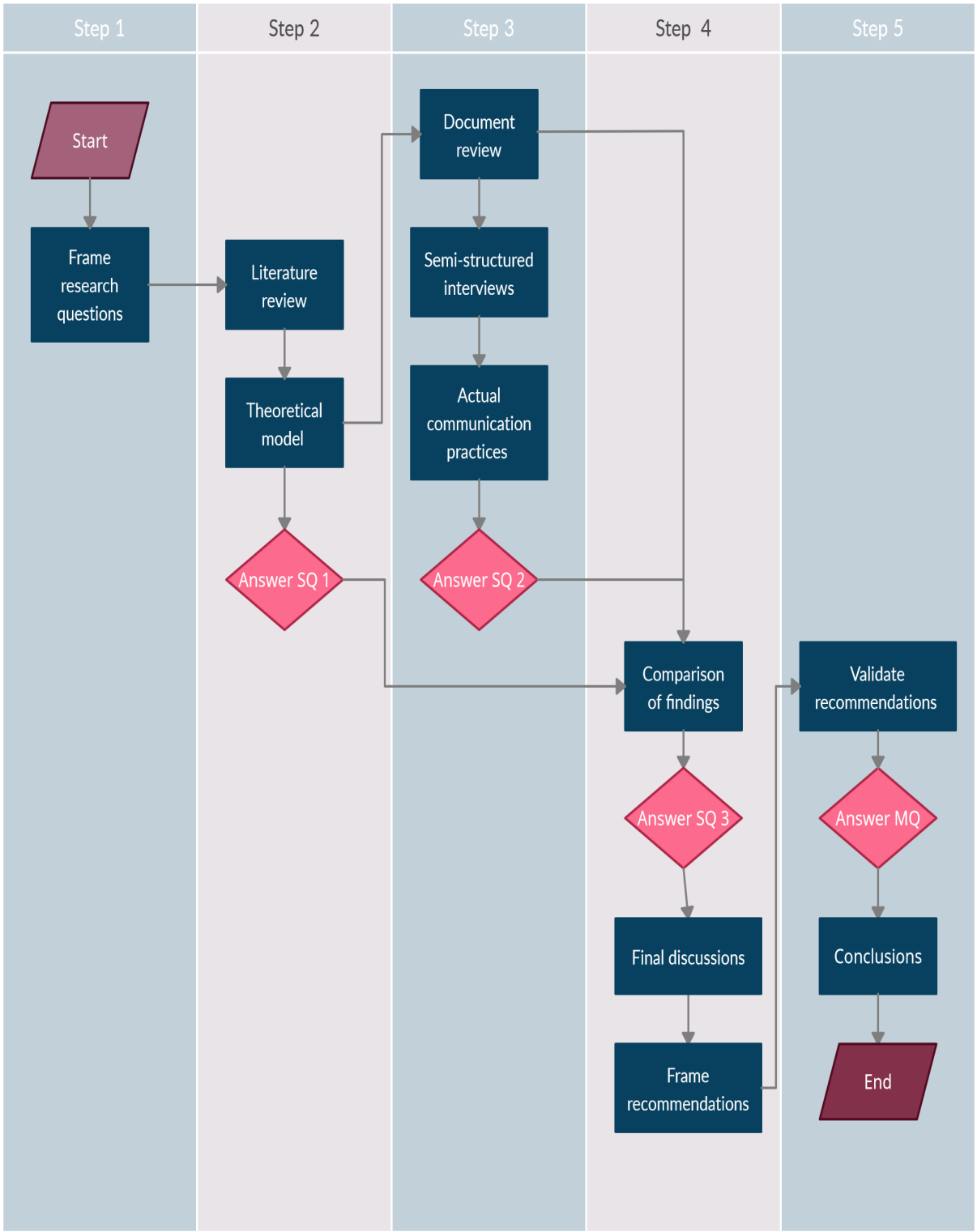

Figure 3: Flowchart describing the research method.

3. Literature review

Why?

This literature review is used to understand the relevant published studies that would help to answer the first sub-question.

What?

Through this chapter, the term communication is defined and its significance to a team is described. Furthermore, the elements that describe the communication practices of a design team are explored, and the role of these elements in achieving project success is described.

How?

By following an elaborate procedure for identifying, selecting, and scrutinising the previously published studies describing communication practices of a design team and its relationship with project success.

3.1 Introduction to communication in a design team

Communication within the design team could be expressed as a network between a sender and the recipient connected by means of communication. Through communication, the members of a design team share several things, such as project data, thoughts, and skills (Safapour, Kermanshachi, Kamalirad, & Tran, 2019). A similar description of communication was provided by Senescu et al. (2013). They state that communication is a method of exchanging data or messages between a source and a recipient for facilitating the work process in the team and having a mutual understanding of the information shared (Senescu, Aranda-Mena, & Haymaker, 2013). Apart from sharing information, communication is seen as a link that binds the different individuals working in a team (Nipa, Kermanshachi, & Kamalirad, 2019).

The importance of communication for successful teamwork in the design stage of a project is expressed by various scholars. Communication is considered to help a design team work better by promoting and strengthening key team processes including coordination of tasks and development of project plans (Marlowa, Lacerenzab, Paolettia, Burke, & Salas, 2018). Further, communication facilitates in sharing of information and opinions, which is particularly important for a design team as the task of the individuals working in the team are interconnected (Safapour, Kermanshachi, Kamalirad, & Tran, 2019). The information and opinions shared not only serve as an input for the different tasks but also serves as a basis on which the team makes its decision regarding the project (Liu, Baldwin, & Shen, 2006).

Otter et al. (2008) state that individuals working in a team continually develop new information and awareness about the design through gathering, exchanging, and transforming information.

Nonetheless, these individuals often work on a task individually, and thus the role of communication becomes critical for facilitating and stimulating developing a cohesive final product by the team (Otter & Emmitt, 2008).

Senescu et al. (2013), in their work, describes that scholars in the field of construction management have previously distinguished knowledge from information. This concept is also prevalent in information management where information is distinguished from data. However, these scholars conclude that this separation is not essential in developing an understanding of team communication, since individuals must share all three of them for successfully designing a project (Senescu, Aranda-Mena, & Haymaker, 2013).

In literature, communication is designated as an integral factor in delivering a successful design for a project (Kamalirad, Kermanshachi, Shane, & Anderson, 2017). The research of Nipa et al. (2019), found that communication in a design team had a direct impact on factors such as decision-making, clarity of project scope, social and technological assistance provided by team members, and problem-solving, all of which were consider as elements contributing to project success. Marlowa et al. (2018), showed that communication was associated with project success since important task-related information was distributed within the design team through it.

Although many researchers have focused on and highlighted the importance of communication in achieving successful project results, Nipa et al. (2019), state that the topic of team communication still needs to be further analyzed for understanding its association with project success.

3.2 Attributes of communication

The attributes that help to examine and explain communication within a project team at a micro level are discussed in sections 3.2.1 to 3.2.3.

3.2.1 Level of communication

In a design team, there are various levels at which communication takes place. Various authors have discussed this using different terminologies. Emmitt et al. (2003), describe that communication among the members of a project team can be classified into three levels: interpersonal communication, small group communication and multi-group communication.

The first level, interpersonal communication, refers to the situation where individuals establish contact with other individuals to facilitate the transmission and comprehension of knowledge and information (Dainty, Moore, & Murray, 2006). Through interpersonal communication team members develop and sustain relationships on an individual level (Emmitt & Gorse, 2003). Dainty et al. (2006), described the second level, team communication, as a situation in which a group of individuals working in the same department, or a section of a company communicate with each other. Emmitt et al. (2003), explained that having communication at this level empowered the members of the group to organize their tasks and discuss their opinions on them. The final level

is multi-group communication, and it relates to groups working on different tasks communicating at an organization level (Dainty, Moore, & Murray, 2006). Thus, Dainty et al. (2006) termed this as organizational communication. The purpose of communicating at this level is to organize different tasks performed by different diverse groups (Emmitt & Gorse, 2003).

However, Safapour et al. (2019), mentioned that communication inside a design team can be classified into two directions instead of three levels. The purpose of representing communication in terms of direction was to show the flow of information (Safapour, Kermanshachi, Kamalirad, & Tran, 2019). Safapour et al. (2019), used the term vertical communication to show communication between an individual and his manager. The term vertical depicted the flow of the information in the forward and backward directions. Whereas horizontal communication described the communication between different disciplines inside the team and communication between two different organizations. The term horizontal represented the flow of the information in a lateral direction. **Figure 4** illustrates the directions in which communication takes place in a design team.

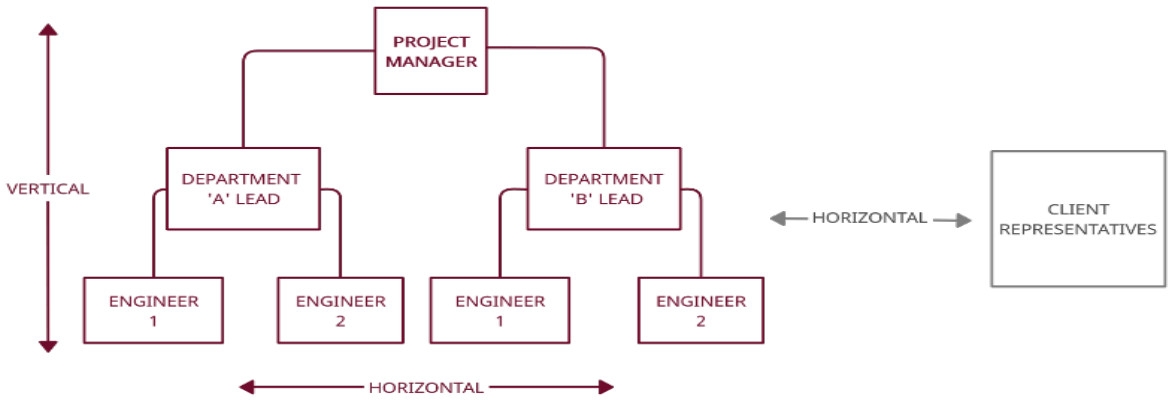

Figure 4: Depiction of various levels at which communication takes place

The common feature shared by these levels is that the choices of the communication medium which can be used remain the same (Otter & Emmitt, 2007). However, it is understood that the choice of communication medium used plays a significant role in the amount of information that can be sent, and its understanding by the recipient differs from every communication medium (Oke & Idiagbon-Oke, 2010).

3.2.2 Means of communication

The means of communication are described as the ways or the medium through which individuals working in a design team exchange their ideas, views, and data (Otter & Emmitt, 2007). Oke et al. (2010), state that the medium of communication is one of the necessary aspects required to be examined for comprehending the communication practices of a team Otter et al. (2007), described that the means of communication used by the individuals of a design team can be categorized under face-to-face approach or technological means. The face-to-face approach

encompasses means of communication like a face-to-face conversation between individuals, and group discussion or meeting. Whereas the other category encompasses means of communication like phone calls, emails, video conferencing applications (Otter & Emmitt, 2007).

Further, Otter et al. (2007), also categorized design team communication based on the time at which communication takes place. Communication among the design team happening at the same time is called synchronous communication. Whereas communication among the design team happening at a different time is called asynchronous communication (Otter & Emmitt, 2007). Based on this, communication taking place via face-to-face conversation, meeting or video conferencing was called synchronous communication, and communication taking place via technological means like email was called asynchronous communication.

Safapour et al. (2019), in their work, describe the purpose for which individuals should use synchronous communication in the design stage of a project. They state that to discuss the task done by a member on an individual level, a design team should use face-to-face conversation. Whereas the meetings can be used for a variety of reasons. One of them is to discuss the work done by different disciplines concerning the project. The objective of such a meeting is to share information and get the perspective of different individuals working on the design of a project (Safapour, Kermanshachi, Kamalirad, & Tran, 2019).

In their findings, built on experimentation and observational evidence, Otter et al. (2007), concluded that in situations that required the design team to reach an agreement, the use of synchronous communication was found to be more effective as compared to asynchronous communication. The reasoning provided for this was that the team members could communicate continuously to reach an agreement by using means of communication such as face-to-face conversations and meetings (Otter & Emmitt, 2007). Likewise, other scholars found that emails were effective in situations that required the team members to just share information and not reach an agreement (Oke & Idiagbon-Oke, 2010).

Apart from this, the means of communication can also be distinguished based on the criteria of the speed of communication, the richness of the information exchange, and the amount of project information to be sent. Based on these features the different means of communication discussed can produce distinct output (Cheung, Yiu, & Lam, 2013). The definition of the richness of information exchange was provided by Oke et al. (2010). These researchers stated that the richness of information exchange is the capacity of a communication medium to transfer data effectively. Based on this definition, they stated that means of communication like face-to-face conversation and meetings provided high richness as more data could be effectively communicated through them. While tools like emails and documents were said to have low richness in information exchange (Oke & Idiagbon-Oke, 2010).

Further, Oke et al. (2010), exclaim that to comprehend the communication practices of a design team, two aspects should be considered. These are the means of communication, and the frequency at which these means of communication are used.

3.1.3 Communication Frequency

The number of instances when different communication means are used in a design team is represented by the frequency of communication (Cheung, Yiu, & Lam, 2013). Cheung et al. (2013), advocated that frequency of communication plays a vital role in a project as the capability of an individual to provide relevant information for preparing the design keeps on transforming, and this modified information needs to be shared with other team members.

Various researchers have tried to correlate the frequency of communication with team efficiency (Cheung, Yiu, & Lam, 2013), (Patrashkova-Volzdoska, McComb, Green, & Compton, 2003). However, the purpose of correlating the frequency of communication with the team efficiency differed. Cheung et al. (2013), stated that when members of a design team communicate frequently, then they can analyse the design prepared by them from a different point of view and observe new challenges in integrating different works. Apart from accumulating information provided by multiple channels, high communication frequency allows the team members to suggest modifications and provide constructive feedback to each other. This helps the team to make rational decisions and thereby improves team efficiency (Cheung, Yiu, & Lam, 2013).

However, Patrashkova-Volzdoska et al. (2003), used performance indicators such as task accomplishment, the collaboration of a team and the rate of data processing by individuals in their study to measure team efficiency. Through their studies, they showed that a high communication frequency allowed the individuals working in a design team to grasp more information and accomplish a task quickly. Also, increased communication between the design team members improved their relations with each other (Patrashkova-Volzdoska, McComb, Green, & Compton, 2003).

Chiu (2002), in his work, described that the frequency of communication varies based on the type and the size of work undertaken. The task of complex nature required high communication frequency as compared to the routine task performed by the design team (Chiu, 2002). Moreover, they observed that the communication frequency within a discipline was more than the communication frequency involving different disciplines. They attributed this to the ease of meeting a person at a place, and the availability of the member based on their schedule (Chiu, 2002).

The analysis of literature at a micro-level yielded that the attributes describing the communication in the design team can be broadly classified into three categories. These are the level of communication, communication tools and communication frequency. **Figure 5** shown below illustrates three attributes of communication.

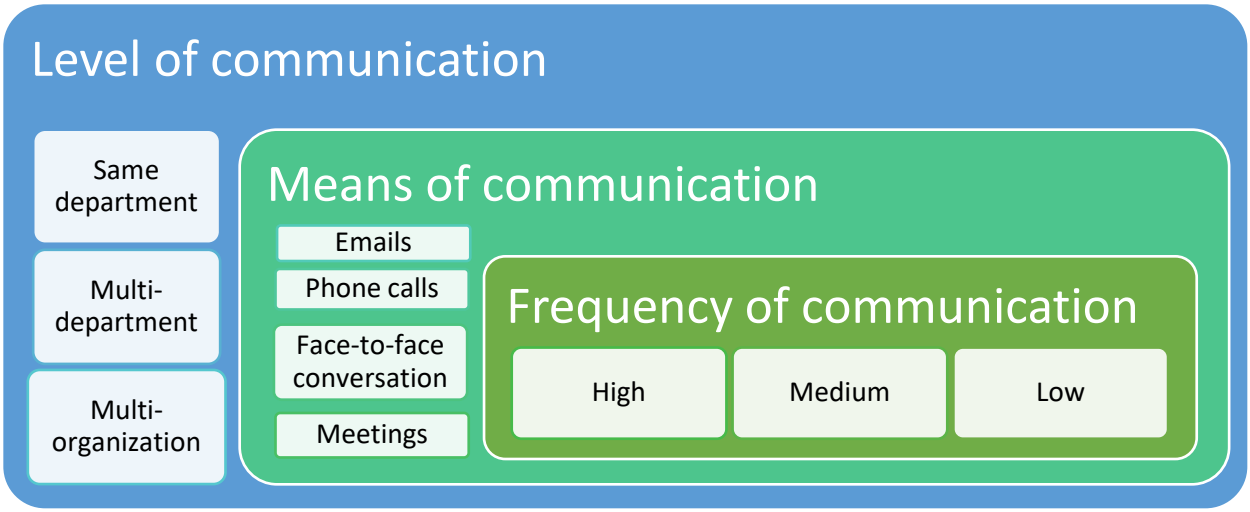

Figure 5: Attributes of communication in a design team

3.3 Communication for project success

Mavuso et al. (2016), describe that there are numerous factors associated with team communication, and which play a crucial role for a team to achieve project success. Senescu et al. (2013), evaluated the relationship between project complexity and team communication. The evaluation of team communication was done using criteria like team collaboration, frequency of sharing data, and understanding of information produced within the team. Using a case study these scholars showed that to overcome the challenges of increased project complexity communication within the design team increased since this allowed the design team to reflect and develop on their work.

Kamalirad et al. (2017), observed that a tight project schedule has a considerable influence on the communication between professionals, as the development of documents and engineering drawings for projects with strict deadlines demanded additional communication and engagement between these individuals. The research of Tran et al. (2017) on effective communication practices for a design concludes that timely sharing of information is an effective practice in the design process. These researchers found that prompt responses to questions about the project's design from individuals ensured that the design process progressed smoothly.

Otter et al. (2008), commented that project managers should view group discussions and individual conversations as valuable tools for strengthening team collaboration. Since these communication mediums act as a binder within the team and promote socio-emotional engagement, which further leads to individuals having a better understanding of the project (Otter & Emmitt, 2008). On the other hand, Jha et al. (2006), state that, frequent design integration meetings between different disciplines working independently, and short and informal communication channels help to ensure that the quality standard desired from the project are met.

Marlowa et al. (2018), conducted a meta-analysis to identify the relation between team communication and team performance. The results of their research showed that teams in which individuals were familiar with each other, communicated frequently and performed better than the teams in which individuals were not familiar with each other.

Nguyen et al. (2004), in their research work, found that extensive communication within a discipline and across different disciplines was a critical aspect for guiding and integrating individuals working in the team, as well as making decisions, to achieve project success. This is also supported by the findings of Cheung et al. (2013), who state that communication between individuals from diverse backgrounds facilitates having constructive dialogues in a team and pursues rational decisions for a project.

The relationship of different communication practices with project success described through the discussions in this section is summarized in **Table 1**.

Table 1: Communication practices leading to project success identified through literature.

Attribute of communication	Communication practices	The aspect of project success	Reference
Frequency	Increased frequency	Overcoming project complexity	(Senescu, Aranda-Mena, & Haymaker, 2013)
		Managing tight schedule	(Kamalirad, Kermanshachi, Shane, & Anderson, 2017)
	Prompt response	Smooth design process	(Tran, Nguyen, & Faught, 2017)
Means	Group discussions	Engagement of individuals with the project	(Otter & Emmitt, 2008)
	Individual conversations		
	Design integration meetings	Quality assurance	(Jha & Iyer, 2006)
	Short & informal communication channels		
Level	Familiarity of team members	Team performance	(Marlowa, Lacerenzab, Paolettia, Burke, & Salas, 2018)
	Multidisciplinary interactions	Rational decision making	(Cheung, Yiu, & Lam, 2013), (Nguyen, Ogunlana, & Lan, 2004)

3.4 Communication barriers

Previously published literature confirmed that there are numerous barriers to effective communication in a design team, which limit it from achieving successful project results (Kwofie, Aigbavboa, & Thwala, 2020). To define, communication barriers are the attributes of a network of communication established in a project organization, that restrict the sharing of knowledge, data or other material being exchanged through communication (Thomas, Tucker, & Kelly, 1998).

Xie et al. (2000), conducted a survey to test the relationship between the performance of a team and communication problems in the design stage of a project that were outlined in the literature. Their findings indicated that lack of coordination was one of the main problems in the design team which resulted in producing conflicting information.

An increase in the usage of contemporary electronic interaction tools inside an organization tends to reduce face-to-face interaction, which then affects the creation of trust among the working relationship of individuals in the workplace (Cheung, Yiu, & Lam, 2013). Liu (2006), in his research, described that, if there was a lack of trust, individuals mostly relied on their own opinions and perceptions, and that produced a lot of conflicts in the environment in which the design team operated.

Dainty et al. (2006), explained that the capacity of each communication medium to transmit information varied, and information conveyed through a wrong communication medium forced the consumer of the information to process much more data than a particular communication medium should provide. The research findings of Santalova et al. (2019), described this situation as information overload. These researchers found that this situation at first did not allow an individual to analyse and utilise the information properly. Second, this further translated into disturbances throughout the information sharing cycle and a significant reduction in the performance of the entire system. (Santalova, Lesnikova, Nechaeva, Borshcheva, & Charykova, 2019).

The construction of a project usually requires various experts possessing different expertise to collaborate and develop a design (Tai, Wang, & Anumba, 2009). Tai et al. (2009), explain that individuals could have a dissimilar comprehension and perspective of the project they are developing based on their area of expertise. Dainty et al. (2006), further explained that when individuals used specific technical concepts and vocabulary used in their field, which were not known to other members during a multidisciplinary team meeting, it resulted in individuals having a difference in understanding for the information being conveyed.

Thomas et al. (1998), in their study of critical communication variables, described that communication is often impacted by project features including the management framework, team structure and the scale of the project. A weak management framework led to insufficient involvement of relevant team members in the crucial meetings. Besides this study also concluded that meetings where the members were not given an equal opportunity to contribute or if the

right individuals were not selected to participate in the meetings, led to a lack of crucial information required for the decision-making (Thomas, Tucker, & Kelly, 1998).

The research of Kwofie et al. (2020), found out that design teams are diverse in terms of the cultural and professional expertise individuals working in a design team possessed. Based on this they stated, this diversity created unique demands in terms of communication these individuals needed to have for their task or social-based conversations. However, a failure for recognising this diversity by the individuals during their communication with other members of the team created conflicts (Kwofie, Aigbavboa, & Thwala, 2020).

The relationship of different communication practices which serve as a barrier to project success described through the discussions in this section is summarized in **Table 2**.

Table 2: Communication practices serving as a barrier to project success identified through literature.

Attribute of communication	Communication practices	The barrier for project success	Reference
Frequency	Lack of coordination	Conflicting information	(Xie, Thorpe, & Baldwin, 2000)
Means	Reduced face-to-face communication	Lack of trust	(Cheung, Yiu, & Lam, 2013), (Liu, Baldwin, & Shen, 2006)
	Choice of communication medium	Information overload	(Dainty, Moore, & Murray, 2006), (Santalova, Lesnikova, Nechaeva, Borshcheva, & Charykova, 2019)
Level	Use of discipline-specific vocabulary	Difference in understanding	(Dainty, Moore, & Murray, 2006), (Tai, Wang, & Anumba, 2009)
	Weak meeting structure	Lack of information for decision-making	(Thomas, Tucker, & Kelly, 1998)
	Failure to recognize diversity	Team conflicts	(Kwofie, Aigbavboa, & Thwala, 2020)

Summary

Through this chapter, the relationship between communication and project success was described in detail. At first, the definition of communication in the context of the design phase of a construction project was provided, and its importance was explained. Further, the three attributes which described communication were presented. These three attributes were level of

communication, means of communication and frequency of communication. Using the said three attributes as the basis, the relationship of communication with project success was described. Through **Table 1**, the communication practices which lead to project success were explained. Likewise, **Table 2** described the relationship of different communication practices which serve as a barrier to project success. Further, the findings represented through these tables are merged to develop a theoretical model to represent a comprehensive relationship between communication with project success. This relation is illustrated in **Figure 6**. The three attributes of communication are depicted as three pillars (triangles) of communication. The elements depicted in green are the communication practices that lead a team to project success. Likewise, the elements depicted in red are the communication practices that serve as a barrier for the team to achieve project success.

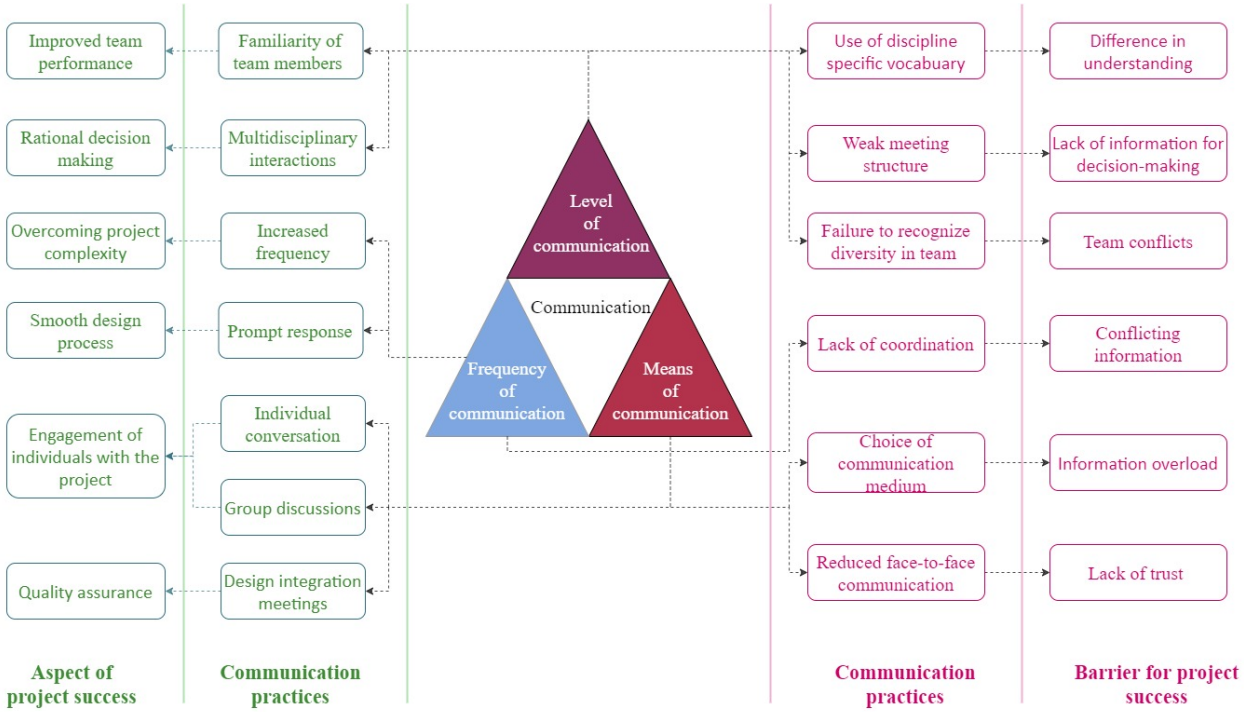

Figure 6: Theoretical model on team communication

4. Desk review

Why?

This chapter develops an understanding of the communication procedures used by a design team, which help to partially answer the second sub-question.

What?

Through this chapter, the documents describing the communication procedures to be followed by people working in a design team, and the project success factor described by these documents are discussed.

How?

By conducting a document review to identify and scan the documents describing procedures set up by a design team for project communication.

4.1 Document review

Over the last few years, Bilfinger Tebodin had noticed that working procedures for a task varied from project to project, and the performance of the team in terms of finishing the project in time, budget, and scope, also varied. Since the company was not able to examine the relationship between how the tasks were performed in projects and the results obtained, the company started to develop a system called '*Practices*' (fictitious name used for confidentiality purposes). The purpose of developing this system was to capture the working procedure of all the tasks taking place during the lifecycle of a project. By defining these procedures for the daily working of the team, the company intends to have a standardized way of working for all projects and thereby achieve consistent results across the projects. To develop these procedures, guidelines provided by PMI (Project Management Institute), and ISO (International Organization for Standardization) were used. For this research, all the documents describing procedures related to communication to be followed by individuals during a project were extracted from this system.

Practices mention project communication as a separate process under the 'P*roject management*' tab. This process describes the communication responsibilities of the project manager, the contract manager, and the procurement manager concerning the client and the project team in the form of a diagram shown in **Figure 7**. The procedures for project communication are linked to this diagram. Besides, procedures related to project communication are also mentioned in the project execution plan (PEP) drawn up by the project team. The PEP is not mentioned under the 'P*roject management*' tab as the team has a basic template of it, which is modified before the start of every project to accommodate the wishes of the client.

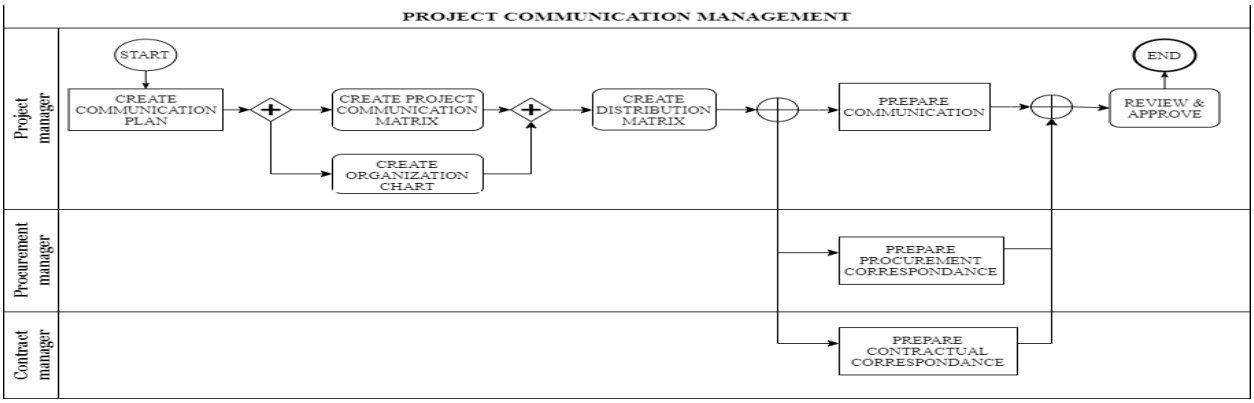

Figure 7: Working procedure for project communication as depicted in Practices

4.1.1 Practices

The first element in this diagram represents the procedure related to the creation of a '*Communication plan*' to communicate with the client. This provides guidelines for preparing a stakeholder management plan and aligning the performance expectation with the client by getting his feedback. Using this communication plan, the organization chart of the team and a distribution matrix are created. The distribution matrix covers the deliverable types, responsibilities, and accountability of every team member.

The second element is the creation of a '*Project communication matrix.'* In this, the project manager shall define the meeting types and how they would be executed. The matrix comprises of agenda of the meeting, participants of the meeting, the frequency of the meeting and expected outcomes of the meeting.

The third element is titled '*Prepare communication.'* This describes how the documents produced by the project team during the project are to be managed. The documents are given a unique document number and are constantly updated and stored in a document management system. The creation of documents and their usage is shown through an extensive logic diagram in this element. The logic diagram maps out the steps to be followed while developing a document and it further assigns roles to be people for checking the consistency of information written in the document produced by individuals.

The diagram briefly explains the role of the contract manager and the procurement manager. As per the diagram, the contract manager prepares contractual correspondence, and the procurement manager prepares procurement correspondence. These elements describe the procedure for managing the communication and the correspondence of documents with the client and the vendors.

On analysing this diagram further in detail, some rules for the use of means of communication by the members of the design team were found. These rules were placed as notes attached to the objects in the diagram. The rule regarding verbal communication (face-to-face, or by

telephone) instructed that agreement made through this form of communication, which is of vital importance, in terms of scope, budget, technical issues and so forth, shall be later confirmed in writing.

The rule regarding email was more focused on describing email to confirm verbal agreements with the client or third parties. The note instructed that the author of the email is responsible for correct processing, and he shall confirm the receipt of the email by the addressee. In case of contractual nature, the email content should be first discussed with the Project Sponsor. This note also makes the employees aware that the use of email may lead to binding commitments. The final remark in this note was that, in principle, the Project Manager should submit the outgoing correspondence. If a prior agreement was made, project team members may submit emails to external parties. However, the project manager shall then be included in the copy.

To ensure consistency in every task, *Practices* also provides documents that are titled '*Work instruction_X'* to provide elaborate instruction on working procedures for the different tasks. The four main components of these files are Starting considerations, Process task, Final product, and Responsibility assignment matrix. These documents contribute to project communication by providing a clear list of people who are involved in a task and who need to communicate with each other for a task.

4.1.2 Project execution plan

For every project, a PEP is drafted in consultation with the client, with the primary objective of defining the execution approach and ways of working in the project. Development of the PEP is used as the first step for team building in a project. Since through it, a mutual understanding of the client's requirements and expectations, are discussed and defined. In the PEP, communication management is defined as a separate chapter.

The chapter defines the work locations where the project team operates and instructs that the communication between all the parties, written and spoken, shall be in English. The document states that the use of verbal communication (face-to-face or by using telephone/video call) is encouraged as it helps to develop a mutual understanding of a task, and it instructs that verbal agreement shall be confirmed in writing using e-mail. To overcome the language and/or time difference obstacle, questions asked in emails should be supported with remarks and figures (drawings, etc.). Additionally, the subject of the email should be in the format specified in the document.

The document also specifies the several types of meetings to be conducted during a project by describing the attendees, frequency, and the goal of the meeting. The actions, information and decisions from meetings shall be recorded in the external communication register and should be shared with the client after each meeting. The document further describes the various software

the team would be used for working and sharing information with the client. Finally, it instructs the team to follow the communication line set up while communicating with the client.

Table 3 presents an overview of the communication practices defined across various documents.

Table 3: Communication practices leading to project success identified through documents

Attribute of communication	Communication practice	The aspect of project success	Reference
Frequency	Frequent meetings	Achieving expected outcomes	Project communication matrix
Means	Documenting verbal agreement	Providing confirmation for agreement	Additional notes
	Focused meetings	Achieving expected outcomes	Project communication matrix
	Encouragement for face-to-face communication	Mutual understanding	Project execution plan
Level	Stakeholder engagement plan	Alignment of expectations	Communication plan
	Document management system	Consistency of information	Prepare communication
	Working procedures	Clear responsibility & accountability of work	Work instruction_X

Summary

Through this chapter, the different documents describing the communication practices of a design team were analysed. This document review was undertaken to understand how using these documents a design team wants to define the team's communication practices for achieving project success. The seven communication practices found were frequent meetings, documenting verbal agreement, focused meetings, encouragement for face-to-face communication, stakeholder engagement plan, document management system, and working procedures.

Nevertheless, these documents were primarily focussed on improving the communication with the client and the vendors. Besides, these documents also do not show that if the communication practices defined in them, are performed by the team or not. Thus, a complete understanding of how a design team communicates in practice could not be developed. For this further exploration beyond these documents is required.

5. Interviews

Why?

This chapter is used to explain the use of semi-structured interviews as a qualitative research method for gathering and analysing empirical data for this research.

What?

The concept and the reasoning for selecting semi-structured interviews, and examples showing the application of the various steps describing how semi-structured interviews were conducted in the context of this study.

How?

By identifying and studying the previously published literature describing the use of semi-structured interviews.

5.1 Introduction

The previous chapter described the various documents which serve as guidelines for the communication practices the team should follow. However, those documents did not describe that if the communication practices defined in them, are performed by the team or not. Therefore, semi-structured interviews were carried out to investigate, "*How does a design team practices communication?"*

The choice of selecting semi-structured interviews (SSI) over surveys or open-ended discussions for collecting data for this research is motivated by the following objectives fulfilled by this interview technique (Adams, 2015).

- First, SSI helps a researcher to investigate potential clues during the interaction and steer the interview with an interviewee as every open-ended question can be followed with a follow-up question that enables a researcher to get an answer for the question on the desired topic.
- Second, since SSI involves some open-ended questions, it allows the researcher to get the individual reflection of the interviewee on every topic that is discussed during the conversation.
- Third, SSI is conducted on an individual level. Therefore, bias created in the answers of the interviewee due to the presence of other individuals from the team can be eliminated.
- Fourth, the response of the individuals to the questions in SSI is not restricted to numbers or agreement and disagreement as in the case of surveys. Rather, in SSI the individuals are encouraged to provide reasoning for their answers.

The data for this study was collected by conducting semi-structured interviews, and therefore the type of data collected is qualitative. An interview protocol comprising a set of questions and

topics which must be discussed during the interview was designed to maintain consistency and eliminate the potential for bias.

5.1.1 Interview Protocol

An invitation mail was sent to the selected interviewees describing the purpose of the meeting and to enquire about their free time for setting up the meeting.

Before starting the interview, the purpose of conducting the study was made known to the interviewee along with the role they played in this study. To maintain the privacy of the interviewee, it was also made known to the interviewee that the meeting would be recorded and later the discussions taking place during the meeting would be transcribed.

At the start of the interview, four general questions were asked to the interviewee to get them familiarised with the interviewers and the topic. These questions were later followed by nine questions that enquired about communication in the design team. These questions were framed based on the attributes of team communication and other topics found via the literature study. In particular, the motive of these questions was to know about the experience of the interviewee with the communication practices followed by the team and the challenges they faced regarding them.

For the last few questions, the interviewee had to provide his suggestions for overcoming the challenges the team faced in his perspective regarding communication practices followed by the team. Following it, the interviewee was asked to summarize the whole interview in a few sentences to reflect on the core topics discussed during the interview.

To conclude the interview, the interviewee was asked to give a reference for one of his colleagues with whom a similar type of interview could be conducted. Moreover, the interviewee had to provide his feedback on the interview conducted and suggest ways to improve it.

The interview was planned to have a flexible duration of 30 to 45 minutes. The purpose of keeping the duration of the meeting flexible was to account for the difference in the depth of answers provided by different interviewees.

On the completion of transcribing the interview, the interview transcript was first shared with the interviewee to check the information provided by him was transcribed correctly, and no confidential information was made public. Upon receiving confirmation from the interviewee, the transcripts were later used for data analysis and were also shared with the graduation committee members. A sample questionnaire used for conducting the interviewees is shown in **Appendix B: Sample interview questionnaire**.

5.1.2 Recruitment and sampling of participants

Criteria 1

The criteria established for selecting participants for the interviews was that these individuals must be a part of the project that the company is currently designing for its clients. Thus, employees of the company working on other projects that are in the execution phase, or who perform an administrative role in the company such as HR and finance were excluded.

Using this criterion, sixty members were identified who were developing a design for projects commissioned by two different clients.

Criteria 2

Since it was not possible to recruit and interview all the members for this study due to time constraint, first a project manager and an engineer were selected at random and were interviewed. At the end of the interview, the interviewee had to provide a reference for a person working in their team, who the interviewee felt could provide useful information regarding the topic discussed and provided reasoning for giving the reference.

Interestingly, the motivation provided by both the interviewees for the reference they gave was unique. Interviewee 1 provided the following motivation for his reference, "*I would like you to interact with people who are very technical and are away from the management side of a project, and project management style of thinking. I would like to know if they produce similar communication strategies for the project. I would suggest the name of X*." While Interviewee 2 gave the following motivation, "*I would like you to interview a young person in the project team, to see his point of view. So, you can also interview someone who is now working here only for 2-3 years ago and has started as a junior in this company*. *I would suggest the name of Y*"

Following this pattern, a total of thirteen individuals were selected as the participants for this research. These thirteen individuals represented the four distinct positions in the team, i.e., engineer, lead engineer, project manager, and engineering manager. Also, the experience these thirteen participants had within the company varied. **Figure 8** illustrates the sampling of the participants based on the positions and the experience they had within the team. The majority of project managers in the participants selected for interviews is attributed to the fact that they oversee multiple individuals, and as a part of their role, they need to communicate with various individuals working under them.

Positions				
	Engineering manager	0	0	1
	Project manager	1	4	1
	Lead engineer	1	0	2
	Engineer	3	0	0
		0-10	10-20	20+
		Experience		

Figure 8: Sampling of participants selected for an interview

5.1.3 Coding and categorising interview data

Before describing the coding process it is important to outline the definition of a code used in this research. Codes are words that clearly and concisely represent the concepts emerging from the collected interview transcripts (Chametzky, 2016). These codes then serve as a medium to convert the original raw information into concrete information, which can be used for analyses. For coding the transcripts of the interview *ATLAS.ti* (version 9) was used, as this software allows the researcher to keep track of codes generated, and later also aids in categorising these codes.

To commence the coding process, three basic codes which represented the different means of communication used by a team as described in the literature were used to segregate the data. These codes were *'face-to-face communication', 'emails', 'meetings'*. Later, based on the observations from the interviews, the code word '*scrum*' was introduced to differentiate the regular engineering meeting from the stand-up meeting. At the end of this process, **134 codes** were generated. The distribution of these codes based on the different means of communication used by a team is shown in **Table 4**.

Table 4: The distribution of codes based on the different means of communication

Code	Code count
Face-to-face communication	50
Email	28
Meetings	41
Scrum	15

To expand on this work, and develop a better understanding of data, these basic codes were expanded to specific codes. This was done by comparing the codes with each other, and the codes that shared common characteristics or qualities were merged to form a specific code. As an example, the statement given by Interviewee 12, "*Sometimes there are eight people in the meeting but two people dominate the meeting and they successfully together solve the problems and leave other six people alone*", was represented by code *'meetings.'* Similarly, the code *'meetings'* also represented the statement given by Interviewee 13, "*There are also some meetings where quite a lot of people are involved, and say more than 50% are listeners. So they don't have an active role in the project."* Since, both statements described the build-up of the participants attending a meeting played a crucial role in how the meetings proceeded a code called '*Build-up of participants'* was created.

Following this process, all the statements represented by basic codes were categorised with the help of 17 specific codes. **Table 5** represents the split of specific codes from the basic codes, and their respective code counts. However, the detailed description of the basic codes and the specific codes is exemplified in the next chapter.

Table 5: The distribution of codes based on different specific codes

Basic code	Specific code	Code count
Face-to-face communication	Feedback	12
	Social interaction	9
	Cross-questioning in direct communication	5
	Bad personal relations	9
	Limited feedback	8
	Individuals working in isolation	7
Email	Traceability of emails	12
	Information sent via emails	6
	Increased frequency of emails	10
Meetings	Multidisciplinary interaction	11
	Small group size	7
	3D modelling software	4
	Build-up of participants	10
	Increased frequency of meetings	9
Scrum	Structured scrum meetings	9
	Unstructured scrum meetings	6

Summary

This chapter presented an introduction to the semi-structured interviews that were conducted as a part of this research and explained the purpose of selecting this method for investigating how do the members of a design team communicate with each other in their routine schedule. To develop an understanding of communication within a team for this research using these interviews a set of different steps were followed. The procedure started by framing a protocol for conducting interviews, selecting a set of individuals working in the design team for the interviews, and it was followed by illustrating the procedure adopted for processing the gathered data.

The data accumulated through these interviews were analysed in two steps. In step one, basic codes were assigned to the data, to depict the concepts or the process related to a means of communication the interviewee is referring to in that phase of the interview. In the second step, the codes which shared common characteristics or qualities were merged to form specific codes.

A detailed description of these specific codes to be given in the next chapter would help to explain the communication practices of a design team. This would further help to describe the relationship between these practices and project success.

6. Empirical Findings

Why?

This chapter develops an understanding of the communication practices followed by a design team, which helps to partially answer the second sub-question.

What?

Through this chapter, the various communication practices of a design team are described, and their link to project success is explained.

How?

By examining the empirical data obtained through the semi-structured interviews and developing a model to show the relationship between project success and the communication practices followed by a team.

6.1 Communication practices

Although **Chapter 4** described the communication procedures adapted by a design team, it did not describe how does a design team communicates in practice? This question was also raised in **Chapter 5**, where the readers of this report were informed that the answer to this question is provided by conducting semi-structured interviews with individuals working in a design team. The data gathered through semi-structured interviews shows that the communication practices of the design team are best described through the means of communication used within the team. Since these means of communication describe the purpose for which they are used and the frequency at which they are used. The means of communication used by the team are described below based on their importance as described by the interviewees (See **Table 4**).

Face to face communication

Face-to-face communication was used in the design team to have discussions with each other. The respondents gave concrete arguments to say that having face-to-face contact with other teammates is easy, fast, and better. The interviewees experienced that they could cross-question each other in real-time and obtain a response from others quickly. Moreover, the interviewees felt that defining the plans and objectives of a task could be done easily by communicating in this manner.

> ***"Face to face communication is the easiest way of communication. You sit next to each other and you can sort it out together."*- Interviewee 8**

Meeting

The interviewees described that meeting played a vital role in a project, as several individuals met and brainstormed solutions for a problem concerning it. Meetings were conducted within a discipline as well as on a multidisciplinary level. Although a project communication matrix was used to set up meetings, the interviewees still raised their concerns about the conduct. First, meetings with long duration were believed to be ineffective as individuals tend to lose focus.

"Another thing that we can always improve a bit is the structure of meetings. Sometimes you know you like have a meeting but there is no agenda, or the meeting runs for hours and then people get sidetracked quite easily"- Interviewee 7

Another interesting concern about the meeting was that various interviewees pointed out that the participants in a meeting could be classified into two categories. The first category of people was described as introverts, silent, passive, and shy. On the contrary, the other category of people was believed to be reactive, extrovert, and dominant. The impact of this was that the second category of people would speak more and steer and dominate the meeting.

"Everyone must get a chance to talk, as shy people might not give their opinion and that is not good for the project. The people who talk more start steering the team and the project, and maybe not in a good direction."- Interviewee 1

Email

Email was found to be the most used communication medium for the project. The purpose of using email was to share documents or to ask questions about a task. The popularity of using email was attributed to two factors: ease of sending emails, and traceability of it. The tracking history was particularly useful as it allowed the respondents to reflect on an agreement made in the past and share the results of it with relevant people.

"One side of email is good as you can always trace it back and it's all written down."- Interviewee 7

However, respondents believed that email was not an efficient medium, and a variety of reasons were given to explain this. The prime concern was that the number of emails received by a person was high, and due to this, the processing of information was slow. Some interviewees also said that email with long content or having a wide attachment would receive less attention from the receiver.

"Sometimes I receive 60 emails per day and I cannot process them all in a day. I pick out the ones I think are important."- Interviewee 9

Scrum

The stand-up meetings combined with the scrum board were used to discuss topics such as the progress of a task, task to be completed and to check if any person/discipline requires

information from others for the task. Interviewees experienced that stand-up meeting were more structured and precise. As a result, the discussions in the meeting were focused and had a good flow. Consequently, this also allowed these stand-up meetings to be completed in a short time. The scrum board used in this meeting was also observed to be more user friendly than the project board the team was previously using. The team members were also in agreement that the scrum method can be utilized more in their company for preparing project proposals or also in the front-end loading phase. The argument presented in this case by them was that these stages of a project require constant communication of the team to solve problems and define the scope of the project.

> ***"Besides that way of communicating is structured with the project board and having short stand-up meetings with the team members to see where the focus is."*- Interviewee 10**

MS Teams

Microsoft Teams (MS Teams) was recently adopted by the design team for their team communication. This is used as a substitute for face-to-face communication, and it also helps to serve as a means of holding general meetings and stand-up meetings. Apart from these purposes, MS Teams is also used for short conversation and sending messages. Through the interview data, the only drawback noted was that it did not replicate the dynamic environment with which scrum meetings were held when people met in a room. This is better understood with the statement one of the interviewees gave.

> ***"I have always been very positive about that way of working. But, it is not so suitable for using it by the screen only as it is very dynamic, and it requires you to get in a big room and talk to each other using stickers extra, and you can't do it on screen."*-Interviewee 6**

6.2 Communication for project success

The communication practices followed by the team which were associated with these means of communication were segregated by using specific codes (See **Section 5.1.3**). Further analysis of the data shows that there were few communication practices which the interviewees described based on their experience helped the team to function well and achieve project success. These practices are described below based on their importance as described by the interviewees (See **Table 5**). In the case of two communication practices of equal importance (based on the count), the importance of the means of communication the communication practice was attached to was used to prioritize.

Feedback

The respondents stated that while having individual conversations in a team, it was important to share feedback. The main purpose of using feedback was to set clear expectations for a task and to have a timely check on the progress of the work. They opinioned that by asking for feedback

individuals could check and establish a mutual understanding of the task and avoid misinterpretation. Thus, in this way, individual conversations were understood to help people develop a better connection with the project.

> ***"Feedback from team members is important. It helps you to know if everything is going well or what frustrations they have. This has to be done not only to solve the problem but also to hear their voice. I think from this the project will benefit, as the people feel that their view is been heard."*- Interviewee 11**

Traceability of emails

The interviewees stated that the function provided by email to trace back documents sent in the past allowed the team members to reflect on those agreements and share the outcomes of the task related to them. From the perspective of the interviewees this form of multidisciplinary interaction was advantageous. However, there were no statements made by them that concluded that these interactions led to making rational choices for the project, as predicted by the theoretical model.

> ***"But, of course, the email form of communication has the advantage that it is traceable and you also can easily share the outcome of the discussion with others by just copying them in."*- Interviewee 8**

Multidisciplinary interactions

The theory said that multidisciplinary interactions between individuals play a crucial role in a project as through them, a team could make rational decisions for a project. In practice, respondents noted that having interactions and meetings with people from different disciplines allowed the team to see a problem from different perspectives. This difference in perception was important to reach the right solution. Moreover, these interactions were also observed to serve as a medium to coordinate and manage the interface between their work.

> ***"Communication in this aspect is vital for proper alignment, in the field of planning and interfaces. To come to the right solution or design for something, one needs to look at it from all relevant angles, like civil, mechanical, electrical, etc. By doing that, you buy everyone's commitment to the outcome."*- Interviewee 3**

Social interactions

Several interviewees stated that having casual interactions with teammates via face-to-face communication or during a meeting helped them to get acquainted with each other and improve bonding within the team. Some interviewees explained that if there were common grounds for discussion between two people then it would be easier for them to talk directly to each other.

The theory mentioned that familiarity with team members was one of the components of improving team performance, and these social interactions helped in that cause.

> ***"For me having direct communication or contact is important. These interactions also help in building a relationship with each other. "*- Interviewee 5**

Structured stand-up meetings

The description of the stand-up meetings given by respondents shows that stand-up meetings were a good way to have quick discussions on how to make progress in work, manage interfaces and discuss the needs of individuals to complete their tasks. These meetings served as a short & informal communication channel the team required to keep a check on the quality of the project as prescribed in the theory.

> ***"Ok in principle it is a very good way that you start your day with few key persons not only from your team but also from the client. You set the expectations for the day and ask if someone needs something from you or if you need something from others."*- Interviewee 13**

Small group size

The interviewees felt that the frequency of using means of communication like face-to-face communication was higher within their discipline as they continuously worked together and could have direct contact with everyone within the discipline. A similar trend was observed with meetings also, as the interviewees felt that with fewer participants, everyone got more opportunities to interact and contribute to the meeting.

> ***"When you are in a smaller team, which is also common within Tebodin, you are with 4-5 process engineers and normally you sit together in a group and you talk a lot. But, when the group becomes bigger, it becomes a bit more difficult."*- Interviewee 9**

Cross-questioning in direct communication

The literature prescribed that having face-to-face communication at an individual level allows individuals to develop a better connection with the project. In practice, face-to-face communication was seen as a medium through which individuals could discuss and question each other over a task. The respondents believed that this cross-questioning allowed individuals to develop a better bond with the project as the goal and plan for a task could be easily defined compared to other communication media.

> ***"For me talking to one another is important, as it helps more. You can say in the verbal communication, like 'do you understand what I am saying' or you can see their reaction to your message. If someone says something or ask for something, you immediately get the answer."*- Interviewee 4**

3D modelling software

Apart from the means of communication described in the previous section, the team also used 3D modelling software to communicate. The 3D modelling software allowed the interviewees to view and check the compatibility of their models with each other and place a comment on the area where their models clashed. This practice was found to be beneficial for the team since these discussions via chat in the software allowed them to identify clashes in the model and reduce major errors and rework the design.

> ***"What is powerful about the software is that it offers a tool called issue tracker. People working on the project can make a screenshot of the problem, write a description of it and assign a responsible person for it and they can communicate."*- Interviewee 12**

The communication practices discussed in this section are summarized in **Table 6**. Further, to make a comparison of these practices with the practices recommended in theory, these practices are also categorised using the three attributes of communication.

Table 6: Communication practices leading to project success identified through interviews.

Attribute of communication	Communication practice	The aspect of project success
Frequency	No specific practice described	None
Means	Traceability of emails	Reflecting on an agreement made in past
	Structured scrum meetings	Quick discussions
	Cross-questioning in direct communication	Plans & objectives of task easily defined
	3D modelling software	Early clash detection
Level	Feedback	Mutual understanding
	Multidisciplinary interactions	Improved problem solving
	Social interactions	Team bonding
	Small group size	More interactions

6.3 Communication barriers

Like communication practices that enabled the team to achieve project success, certain communication practices which disturbed the progress of the team in a project in the experience of the interviewees, were identified and organised based on their impact (See **Table 5**). These practices are described below and later are summarized in **Table7**.

Build-up of participants

The theory described that weak meeting structures can create a lack of information required for taking decisions during a meeting. However, respondents felt that the buildup of the group

attending the meeting played a more critical role, as some people would show more involvement and thus dominate the meeting. This situation was considered challenging because each participant did not have an equal opportunity to express their views on a topic, and this led to meetings and the project being steered by certain individuals. Moreover, the feedback on a topic discussed at the meeting was low, and the solutions that came out of these meetings were biased.

> ***"So the build of the group in the meeting is a barrier as well. Because maybe you are forced to say something and you don't want to be against something, then you don't easily say no I can't do it or its not possible for me to do such thing in such meetings."*- Interviewee 6**

Emails

While investigating the purpose for which emails were used in the team, the respondents reported that a large number of emails exchanged between people in the team was said to create a challenge. Due to many emails exchanged critical data sometimes overlooked, and the time required to process each email increased. Thus, this situation reduced the speed at which the team could function and reduced the time available to the team to complete their tasks in time-bound projects.

> ***"In case of the email you have to go back and forth, and the other person may take a few days to reply, and sometimes you have emails that go 20 times back and forth and you forget what the issue was 20 days ago."*- Interviewee 9**

Bad personal relations

Reduced face-to-face communication was stated in the theory as a cause of lack of trust within the team. Through the interviews, it was understood that the personal relationship between the two people had a significant impact on face-to-face contact between them. The interviewees commented that if the relationship between two people was sore, they would prefer to send emails to each other rather than talk. Many respondents also reported that communication between two people would be reduced if the relationship between them was on a downside or if there was a lack of mutual respect.

> ***"If you like a person you communicate well. If you don't like a person you don't communicate well. You are less likely to inform them about the changes or whatever, and then it goes in a mess."*- Interviewee 12**

Increased frequency of meetings

Some of the interviewees informed that over the past year the frequency of meetings had increased at the cost of the time available for a person to work on his task. However, this created

a challenge for them as their working hours were reduced but the quantity of work to be completed remained the same. The literature said that a lack of coordination among team members can be a challenge for the team, but interestingly the respondents felt that excessive coordination in the form of meetings was also a challenge.

> ***"Sometimes people have 6 hours of online meeting and 2 hours to do their work. In the time when you are in a meeting even if someone calls you, you cannot pick up your phone. I see that in this way the communication is affected, and not in a positive way."*** **- Interviewee 4**

Limited Feedback

The theory described that differences in understanding caused by different views or lack of knowledge on the subject can be a barrier a team may face. While studying this through interviews, respondents described that a lack of feedback shared among people led to unclear expectations from a task and eventually to undesired results. The respondents felt that although there was an open culture for giving and receiving feedback in the company, the practice of using feedback was currently limited, and the team members should provide more feedback to each other.

> ***"What we have missed a lot is that check or double-check kind of thing on all things that have led to miscommunication. Most of the time it's that the expectations are unclear. So what one person wants or what the other person submits or what is expected from him"-*** **Interviewee 10**

Individuals working in isolation

Interestingly, while talking about reduced face-to-face communication, several respondents said that individuals in the team sometimes tend to work in isolation and focus only on their task, thus forgetting about the interfaces. While few others believed that if the team encountered any obstacle in their task the individuals would shrink to their island (stick to their discipline) and stop communicating with other disciplines.

> ***"The engineers are focused on their job and not focused on what others need or want. It's good in the sense that they want to finish their work, but it would be nice if they had a bit wider view. Otherwise, there is the risk that communication will be poor as if team members are working on islands."*** **- Interviewee 1**

Information sent via email

The theory described that the choice of communication medium was crucial, as a wrong communication choice created information overload. In the opinion of the respondents, information overload was created in practice when emails with long attachments or bodies were

sent, since these emails failed to directly address the topic. Moreover, they felt that emails did not guarantee that the other person had fully understood the task.

> ***"Email is the most used system but not the best system for me, as it is very difficult to get an overview of everything. Sometimes I see that people would send me long emails that are not very pinpointed. This creates confusion as I don't understand what they want"*- Interviewee 5**

Unstructured stand-up meeting

Further investigation into the choice of communication medium used by the respondents, revealed that sometimes individuals would start to have technical discussions in these stand-up meetings, which is said to be against the concept of conducting stand-up meetings. Besides, it was noticed that conducting stand-up meetings through MS Teams did not allow the team members to have a concurrent discussion and restricted them from giving their spontaneous feedback on the topic being discussed.

> ***"So in the scrum meeting what you need is a scrum master who is a bit like a dictator. He has to really pay attention to the discussions as engineers tend to go too far on their side of the discussions. They need to be cut off otherwise it would be a waste of time. People just like to talk without making progress."*- Interviewee 3**

Table7: Communication practices serving as a barrier to project success identified through interviews

Attribute of communication	Communication practice	The barrier to project success
Frequency	Increased frequency of emails	Increased processing time of information
	Frequent meetings	Less time for individual tasks
Means	Information sent via emails	Understanding of task not guaranteed
	Unstructured scrum meetings	Lack of concurrent discussions
Level	Build-up of participants	Project steering
	Limited feedback	Unclear expectations from a task
	Bad personal relations	Less communication
	Individuals working in isolation	Interface forgotten

Summary

This chapter presented the empirical findings obtained by conducting semi-structured interviews. Through this chapter, the various means of communication used by the design team and the different communication practices followed by the design team were discussed based on the importance the interviewees gave them. Following it, the relationship of these communication practices with project success was described.

The data analysis revealed the eight communication practices followed by the team which led it to achieve successful results. These were tabulated in **Table 6**. Similarly, **Table7** described eight communication practices that served as a barrier to the team achieving project success. Further, the findings represented through these tables are merged to develop a model to represent the relationship between communication practices followed by the design team and project success. This relation is illustrated in **Figure 9**.

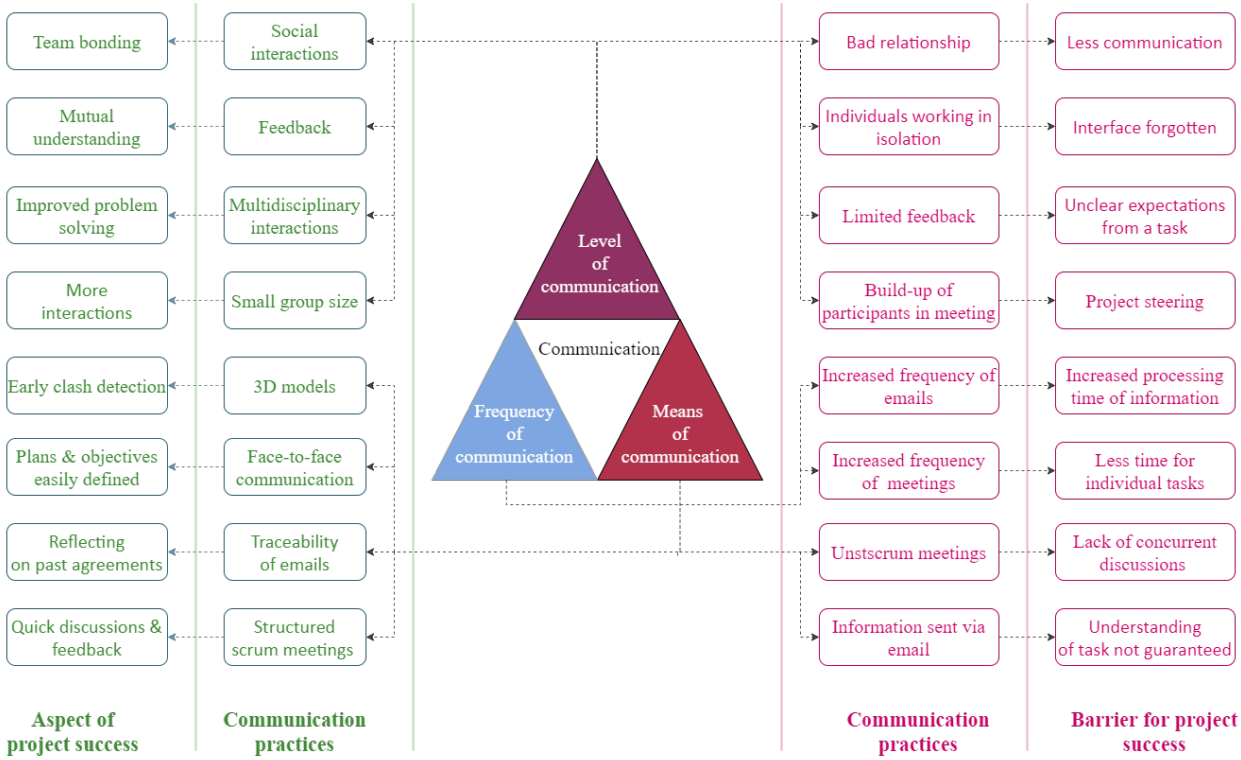

Figure 9: Communication practices followed by the team

7. Results

Why?

This chapter is used to discuss and explain the results obtained for this research.

What?

Through this chapter, the inference of the communication practices followed by the design team is drawn, and the similarities and differences of these practices with the communication practices described in the theory and written in the documents are discussed.

How?

By comparing the results obtained from the literature review, desk review and the interviews, the scope of improvement in the communication practices followed by a design team, and the gap in the theoretical model developed is acknowledged.

In **Chapter 3**, the literature was examined, which gave insights on the attributes that describe the communication of a design team and explained their influence on project success. Besides, interviews were conducted to identify how a team practices communication, and the data gathered through these interviews was explained in detail in **Chapter 6.**

To assess how the communication practices followed by the team described in chapter 6 match those recommended in the literature, a comparison is made. The purpose of this comparison is to identify the communication practices followed by the team that align with the theory and to recognize their point of departure. For this comparison, the theoretical model describing the link between communication and project success is used as the basis. Further, this comparison is explained in two steps. **Section 7.1** describes the comparison of the communication practices which help to achieve project success, and **Section 7.2** describes the comparison of the communication practices which serve as barriers to project success.

7.1 Comparison of communication as a facilitator of project success

The eight communication practices proposed in the theory for project success are compared with the team's communication practice.

Increased frequency

To overcome project complexity and manage tight project schedules, literature suggested increasing the communication frequency because it would allow the team to reflect and develop on their work. In practice, the team had adopted this suggestion and they had continuous interactions and daily meetings within their disciplines and across various disciplines, which had allowed the team to monitor their work and make suitable changes to their plan to achieve the required progress in the project.

Prompt response

A communication practice for the use of the design team recommended in the literature was timely sharing of information with each other and giving a quick response to questions about the project's design to ensure that the design process progressed smoothly. In the communication practice of the design team observed through interviews, it was found that the individuals shared the information regularly. However, the aspect of giving a quick response was questionable in some situations. Since the respondents informed that a large amount of email exchanged within the team increased the processing time of information and therefore the response time also increased, which caused a delay in the progress of a task.

Group discussions & individual conversations

The theory described that group discussions and individual conversations help people develop a better relationship with the project. These interactions facilitate the exchange of social and technical ideas which allows individuals to develop a better understanding of the project. In practice, respondents described giving feedback and having face-to-face conversations on an individual level or during meetings helped the individuals establish a mutual understanding of a task and comprehend the objectives of performing it. Moreover, individuals described that having discussions in a small group was more useful as everyone had more opportunities to contribute during the discussion, and more solutions and ideas for a task could be generated.

Design integration meetings

The literature described frequent design integration meetings between different disciplines working independently help ensure the quality standards desired from the project are met. In practice, the team held several multidisciplinary meetings, one of which was a design review meeting where individuals would talk about the interface and check the alignment of their work with the scope of the project. These meetings ensured the team did not deviate from the project’s scope.

Short & informal communication channels

Another communication practice mentioned by the literature to safeguard quality standards in a project is to have short & informal communication channels, through which individuals can coordinate and manage the interfaces in the design. In practice, the stand-up meeting held by the team replicates this ideology. These meetings were used to bring several individuals to a commonplace to have short discussions on various topics. Moreover, these meetings served as a medium to check whether any person/discipline requires information from others for a task and discuss the changes the team needed to make in its approach to achieving the project goals.

Familiarity of team members

The theory described that familiarity of team members helps them communicate regularly and improve the performance of the team. The design team's communication practices also suggest the same. In practice, individuals described having social interaction allowed them to become familiar with each other and improve their team bonding. This team bonding was essential as it

allowed individuals to easily inform each other about the changes and maintain good coordination.

Multidisciplinary interactions

The theory recommended the practice of having multidisciplinary interactions to have rational decision-making for a project. The design team was seen to practice this too. By having multidisciplinary meetings, the design team could view a problem from multiple perspectives and produce the best technical solution.

Table 8 presents a summary of this comparison by depicting the communication practice followed by the team confirming the theory, leading the team to project success.

Table 8: Comparison of communication practices advised in theory with findings from the interviews

Attribute of communication	Recommended practices	Recommendation followed	Form of practice
Frequency	Increased frequency	Yes	Regular meetings within the team
	Prompt response	No	-
Means	Group discussions	Yes	Group discussions
	Individual conversations	Yes	Face-to-face conversation & feedback
	Design integration meeting	Yes	Design review meeting
	Short & informal communication channels	Yes	Stand-up meeting
Level	Familiarity of team members	Yes	Social interactions
	Multidisciplinary interactions	Yes	Multidisciplinary meetings

7.2 Comparison of challenges due to communication

The six communication practices which serve as a barrier to achieving project success as described in the literature are compared with those which the team experienced as a barrier.

Lack of coordination

The theory described that lack of coordination was one of the main problems in the design team, which resulted in producing conflicting information. The data obtained through the interviews does not conclude that the team faced this problem in practice, and it rather suggests that

practices like having regular meetings and individual conversations were instrumental in maintaining good coordination within the team.

Reduced face-to-face communication
The theory described that reduced face-to-face communication in a team can cause a lack of trust among the team members. In practice, individuals recognized that a bad relationship between two people had a significant impact on the team, as a bad relationship led to reduced communication and sharing of information between individuals, and therefore hindered the functioning of the team.

Choice of communication medium
The literature suggested that communication means used to convey information must be chosen carefully, as the ability of each communication medium to transmit information varied. Moreover, if the information was passed through an error communication medium, it forced the consumer to process much more data than a specific communication method should provide. This challenge was seen in the practices of the design team in two forms. First, the respondents said that sending information by email did not ensure that the other person fully understood the task he needs to perform and the results expected from it. Second, stand-up meetings that should have short discussions on the project were sometimes used to have long technical discussions.

Difference in understanding
The theory mentioned that a multidisciplinary team has individuals possessing different knowledge and expertise. This diversity may result in individuals using a piece of information being conveyed in a different manner than intended due to a difference in understanding and perspective of the information. In practice, individuals faced this challenge as they mentioned that a lack of exchange of feedback in the team often led to people having unclear expectations for a task. This eventually led to unexpected results and increased amount of rework.

Weak meeting structure
The theory suggested that a weak meeting structure could lead to insufficient involvement of relevant team members in crucial meetings and therefore create a lack of information needed for decision-making. In connection with the meetings, the individuals did not encounter this challenge. However, they described the group's build-up, i.e., certain people would express their views more than others and therefore lead the project was a challenge associated with the meeting. This was thought to be a challenge, especially as it led to biased decisions.

Failure to recognize diversity
The literature mentioned that failure to recognize the cultural and professional diversity in the team can cause conflicts within the team. However, during the interviews, no individual suggested that their team communication was hindered due to team conflicts. Instead, they suggested that the coordination in their team was working good.

Apart from the challenges described above, there were three more challenges that individuals believed restricted their team to achieve successful results. First, exchanging many emails

increased the processing time of the information sent through these emails. Second, having a high frequency of meetings in practice reduced the time available to people to work on their tasks. Third, individuals tend to forget the interfaces in the design when they start to work in isolation. However, these challenges were not found in the literature.
Table 9 presents a summary of this comparison by highlighting the similarities and differences between the communication practices which serve as a barrier to project success as described in theory, and the communication practices which the team experienced be as a barrier to project success.

Table 9: Comparison of communication barriers described in theory with findings from the interviews

Attribute of communication	Communication barrier	Barrier observed	Form of practice
Frequency	Lack of coordination	No	-
			Increased frequency of emails*
			Frequent meetings*
Means	Reduced face-to-face communication	Yes	Less communication due to bad relationships
	Choice of communication medium	Yes	Information sent through emails & unstructured scrum meetings
Level	Difference in understanding	Yes	Lack of exchange of feedback
	Weak meeting structure	No	Build-up of group in meeting*
	Failure to recognize diversity	No	-
			Individuals working in isolation*

Note: These communication barriers were experienced by the team, but not found in theory*

7.3 Analysis

The examination of the comparisons made in the above two sections reveals some interesting information regarding the communication practices followed by a team during the design stage of the project.

The first inference that can be drawn from **Table 8**, is that the team is found to practice seven out of the eight communication practices mentioned in the literature for achieving project success. The only communication practice mentioned in the literature that the team was not found to practice was a quick response in the case when the information was sent by email.

Second, three communication practices described in the literature, high frequency of communication, design integration meetings, and multidisciplinary interactions were followed as

it is. Following these allowed the team to keep the project schedule in check, align the design with the scope of the project, and manage the interfaces between their work.

Third, the remaining three communication practices described in the literature, group discussions, individual conversations, and having a short & informal communication channel were found in the practice of the team. However, the team, based on their experience, suggested ways to improve their effectiveness. For group discussions, having a small group size was useful as everyone had more opportunities to contribute during the discussion. Regarding individual conversations, sharing feedback during the conversation was considered to help develop a mutual understanding of the topic. Whereas stand-up meetings were used as a short & informal communication channel.

Fourth, it can be deducted from **Table 9** that only three out of the six barriers mentioned in the theory were found in the practice of the team. However, the team had suggested four other communication practices which were barriers to achieving successful results from their experience that were not found in the literature.

Fifth, the three barriers mentioned in the literature, reduced face-to-face communication, choice of communication medium, and difference in understanding were found to restrict the functioning of the team. Further, using the data from the interviews, bad personal relationships, lack of assurance of the understanding of the information sent via a communication medium, and lack of feedback were understood to be the root cause of the barriers mentioned in the theory.

Sixth, using the description of the impact a communication practice on achieving project success described by the team members (see **Table 5**, and **Section 6.3**), the four communication practices that serve as a barrier to achieving successful results based on the experience of the team need to be added to the theoretical model.

Based on this analysis of the communication practices described in theory and followed by a team during the design stage of the project. The theoretical model developed to represent the relationship of communication with project success (**Figure 6**) is modified to incorporate the arguments made in the above six points. The changed model is illustrated in **Figure 10**. Changes to the theoretical model are highlighted, and communication practices modified in practices for achieving project success are highlighted in green. Whereas, the communication practices serving as a barrier to project success experienced by the team, but not found in theory are highlighted in red.

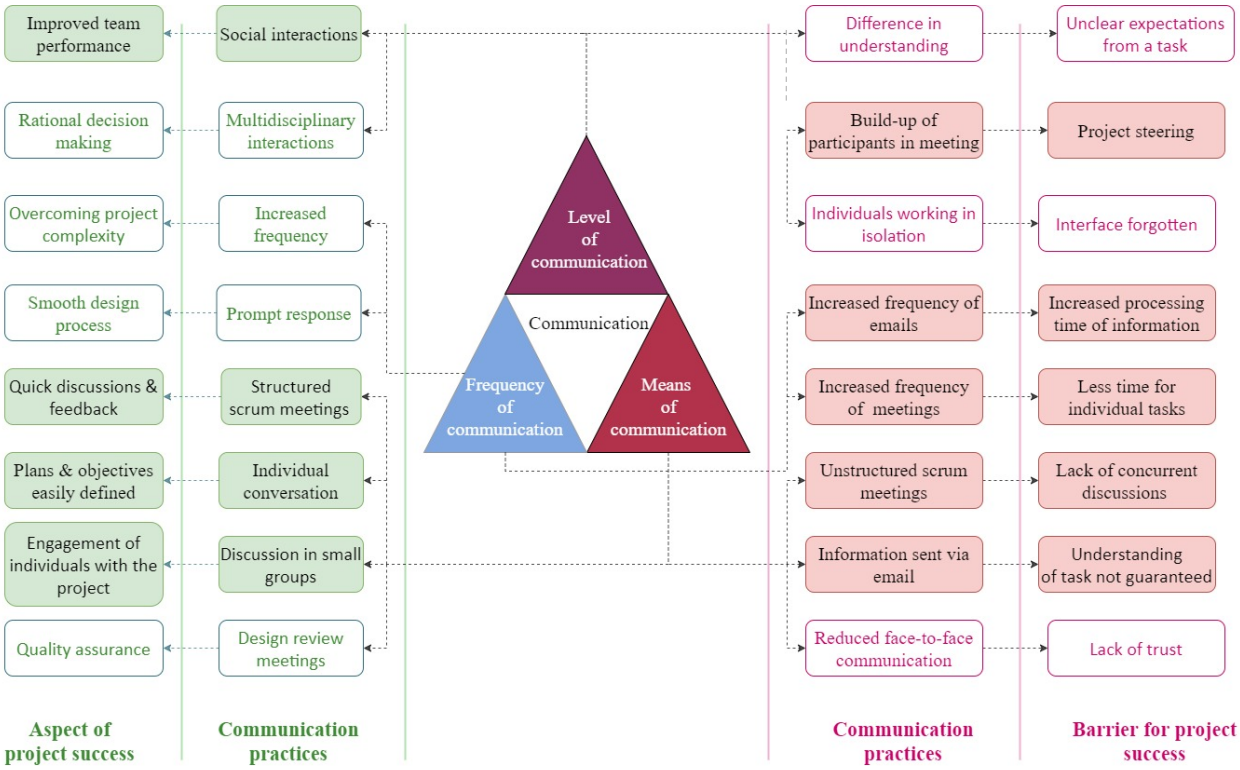

Figure 10: The modified theoretical model

7.4 Comparison with documents

The different documents describing the communication practices of the design team were discussed in **Chapter 4**. In this section, a comparison of the communication practices written in those documents (**Table 3**), is made with the modified theoretical model developed in the previous section (**Figure 10**). The purpose of this comparison is to identify the communication practices covered and the barriers eased by these documents. These documents are compared based on the order described in the team's project management plan.

Project communication matrix

This document is an excel file through which a project manager can describe the different parameters of various meetings conducted for a project, like the agenda of the meetings, the participants, and the frequency of the meetings. Compared with **Figure 10,** this document describes the structure of activities such as the multidisciplinary meeting and group discussions, by defining the frequency and the persons involved in these meetings. Thus, the information provided through this document ensures that individuals have multidisciplinary interactions and group discussions frequently during the project.

By defining the meeting agenda, this document informs individuals about what is to be done in a meeting. But it fails to provide enough information on how these meetings will be conducted.

This is reflected in the practices of the team, as they described that meetings were important for a project, but they also described a few obstacles to how meetings were held.

Prepare communication

This document provides information on the use of the document management system for the storage and management of the various documents prepared by the team. When compared with **Figure 10**, this document tries to mitigate the challenge associated with the coordination within the team, by providing guidelines on activities an individual should perform for preparing, verifying and storing a document.

The design team's communication practices also echoed this objective. As the individuals described that there was no lack of coordination within the team due to mismatch information they used for their work. Following the guidelines on the use of document management systems ensured consistency in the information used as input by individuals for their work and the information mentioned in the source document.

Project communication plan

The project communication plan written for the use of the design team provides basic instruction to the individuals, stating to document verbal agreements made with each other, and later confirm them by sending an email. Compared with **Figure 10**, this document does not describe any specific communication practice precisely. Since the purpose of the instructions written in this document is to make individuals commit to the agreements they make regarding the project.

The communication practices of the design team concerning the use of emails did acknowledge this instruction. Team members described that they used to send information related to agreements via email since they could trace emails and reflect on them at a later stage. However, the instructions on the use of emails are not precisely written in this document, which consequently reflects the challenges the team faces concerning the use of emails.

Working procedures

Working procedures are a set of documents that provide information on the work process and a list of people involved in a task and who need to communicate with each other. Compared to **Figure 10**, this document also tries to mitigate the challenge associated with coordination within the team by providing clear procedures on work processes and the responsibilities of persons associated with them.

The findings from the interviews do suggest that for a task the team had interactions within their discipline and with individuals from other disciplines as specified in these procedures, to produce the necessary results for the project.

Project execution plan

The project execution plan reiterates the project communication practices mentioned in the other documents, and besides, it provides instructions that encourage individuals to have face-to-face communication to develop a mutual understanding of a task. Compared to **Figure 10**, this document attempts to cover the activity of having individual conversations in a team and mitigate the challenge, reduced face-to-face communication.

The team's communication practices suggest that individuals abide by these instructions and have face-to-face communication to develop a mutual understanding of a task. Interestingly, the individuals described that having face-to-face communication with team members also helped improve the bonding within the team. This objective of having face-to-face communication within the team was not stated in the document. Yet the team members felt that using face-to-face communication they could share their feelings and expressions with others, which was important for building a good relationship with a person.

Table 10 presents a summary of the comparisons made in this section. The table shows the communication practice which leads a team to project success covered by these documents and highlights the communication serve as a barrier in the way of the team to achieve project mitigated by these documents.

Table 10: Comparison of communication practices defined in documents with the modified model

Attribute of communication	Communication practice covered	Communication barrier mitigated	Document name
Frequency	Increased frequency	Weak meeting structure	Project communication matrix
		Lack of coordination	Prepare communication
		Lack of coordination	Working procedures
Means	Group discussion		Project communication matrix
	Design review meeting		Project communication matrix
	Individual conversations		Project execution plan
Level	Social interaction		Communication plan
	Multidisciplinary interaction		Project communication matrix

7.4.1 Examination of the comparison

The comparison of documents made in **Table 10** helps to acknowledge a few points and identify the gap in these documents concerning the communication practices defined for the use of the team.

The first inference that can be drawn from **Table 10**, is that the communication practices serving as a barrier to project success defined in the theory like weak meeting structure and lack of coordination were not found during the interviews, since these were already mitigated using various documents.

Second, the barrier, lack of coordination, is mitigated using two different documents. Interestingly, one document mitigates the cause, lack of coordination, and the other mitigating the effect, conflicting information. The document '*Work instruction'* has a section that describes the coordination responsibilities of individuals involved in a task. By clearly defining a list of people involved in a task and who need to communicate with each other for a task, the goal of the team is to ensure that individuals are responsible for completing the task. Likewise, through the procedures written in the document, '*Prepare communication*,' the aim is to ensure that the information used as input by individuals for their work is consistent with the information mentioned in the source document.

Third, these documents cover five out of the eight communication practices described in the model (**Figure 10**), to achieve project success. However, these documents do not have any specific actions described in them which are focused on mitigating the communication practices serving as a barrier to project success described in the same model.

Fourth, the document '*Project communication matrix*' defines the meeting structure. However, it fails to address a soft issue associated with meetings like the build-up of the group attending the meeting. This document specifies a high frequency for meetings, but this creates a practical challenge for the team members, as they must devote more working hours to meetings at the expense of time available to them for their task.

Fifth, the instruction for use of emails within the team is defined in the '*Project communication plan*' on a very general level. The consequence of this is that individuals use emails to send and ask for information through emails very frequently. This high frequency of email then reduced the speed at which the information was processed. Moreover, it restricts the team from prompt response to questions about the project's design to ensure that the design process progressed smoothly.

Sixth, the '*Project execution plan*' does encourage individuals to have face-to-face communication, and the '*Working procedures*' ensure that there is coordination in the team. Nevertheless, these documents do not ask the individuals to give feedback during the task, and this lack of feedback sometimes resulted in individuals producing work that was different from what is expected from them.

Seventh, no document provides guidelines for conducting stand-up meetings, but remarkably, the individuals recognize it as a good medium to have short discussions on how to make progress in work and discuss the requirements of individuals to complete their task. But in this case, not having a formal procedure for holding these meetings reduced the quality of these meetings. Since individuals explained that there was a lack of concurrent discussion in these meetings that

limited them to giving their spontaneous feedback on the topic being discussed. Also, at times individuals would engage in technical discussions.

Summary

In this chapter, first, the communication practices model derived by observing the practices followed by the team was compared with the theoretical model in two steps. The results of the first step in the comparison indicated that the team is found to practice seven out of the eight communication practices mentioned in the literature for achieving project success (**Table 8**). Whereas the results of the second step showed that only three out of the six barriers mentioned in the theory were found in the practice of the team (**Table 9**).

Following this, an analysis of these comparisons was made, and arguments were put forth to modify the theoretical model developed to represent the relationship of communication with project success. The objective of this modification was to incorporate the changes with which communication practices were adapted in practice to enhance their effectiveness and represent the communication practices that served as barriers to achieving successful results, based on the experience of the team (**Figure 10**).

Subsequently, a comparison of this model with the communication practices described in the documents prepared by the team was made. Through this comparison, the gap in the guidelines provided in these documents concerning the communication practices for the use of the team was identified.

The findings of the comparisons made in this chapter serve a two-fold purpose in this research. First, these findings are used to frame recommendations for the changes the team needs to make in the communication practices when the scale of the project changes (small to large). Second, to discuss the theoretical and the practical significance of these results when used in combination with the recommendation framed in this research.

8. Discussions

Why?

This chapter is used to discuss the implications and the significance of the results obtained for this research.

What?

Through this chapter, recommendations for improving the communication practices of a design team are provided, and discussions on the results and recommendations of this research are made.

How?

Using the findings of the comparisons, recommendations for improving the communication practices of a design team are made. Further, these are validated and categorized to highlight their impact and the time required for implementation.

8.1 Recommendations for practice

Based on the analysis and comparisons made in the previous chapter on the communication practices of a design team (**Figure 10**), and the guidelines described in documents relating to these communication practices (**Table 10**), few recommendations are made. The objective of these recommendations is to improve the communication practices of a team and help the team to achieve project success when making a transition from working on a small-scale project to a significantly large-scale project.

1) **Formulating a communication plan**

The team first needs to formulate a communication plan which the individuals can use for their internal communication. Currently, the communication practices which the team needs to follow are described partially across various documents, that are stored at various locations. Thus, creating a scenario, where individuals can forget to read instructions in a document.

Besides, when working on any type of project, the team would first face a challenge in their working, due to the communication practices which serve as a barrier to project success not mitigated by the existing documents (see **Section 7.4**). Moreover, having a concise document explaining the communication practices that individuals need to follow would allow individuals to learn about the purpose of why they need to communicate with each other in a defined way.

2) **Providing equal opportunity to every participant in the meeting**

The structure of various meetings conducted by the design team is well described in the document prepared by the team. However, the results show that the team suffers from the

challenges of individuals dominating the proceedings of a meeting, as the documents don't describe how the meetings are to be conducted.

This can be a significant challenge when working on a complex project, as these types of meetings would produce biased solutions, which might not allow the team to manage the multiple interfaces in the project appropriately. Therefore, by motivating and providing equal opportunities to every participant in the meeting, the quality of discussion in the meeting can be improved and steering of the project by a few individuals can be avoided. The responsibility to assure that everyone gets equal opportunity to speak and contribute should reside with the project manager, or the person leading the meeting.

3) Limiting the number of participants in a meeting

The findings of this research suggest that with an increase in the number of people attending the meeting, the opportunity an individual got to contribute to the meeting was reduced. In the case of making a transition to working on a large-scale project, this challenge would become more prominent. Since with a larger project team, the number of individuals attending a meeting would increase, and that would result in a reduction in the active participation of the individuals in the meeting.

Thus, limiting the number of participants attending a meeting can mitigate this issue. By limiting the number of participants attending a meeting to five, the active participation of the individuals in a meeting can be maintained. If in case, the number of participants increases, then the person leading the meeting needs to ensure that discussions in the meeting are kept focussed, and everyone is kept engaged and active.

4) Adding a feedback loop to the working procedures

The working procedures drafted by the team describe how a task is to be performed and a list of people who are involved in a task, and who need to communicate with each other for this task. Nonetheless, the individuals working in the team reported that even after following these procedures, sometimes the outcome of a task differed from the expected outcome. This problem was caused due to a lack of feedback shared between the individuals during the task.

In the context of a big project, producing undesired results would not only dissipate scarce resources like time and money but even cause scope creep. Thus, adding a feedback loop in the middle of the procedure would serve as a check to identify if the progress of a task is being made in the right direction. Moreover, to provide this feedback face-to-face communication should be used as it allows the individual to establish a mutual understanding of the task.

5) Developing working procedures for stand-up meetings

The results described in the previous chapter indicate, organizing daily stand-up meetings provided an overview of the overall progress made by the team in the project and presented the team with an opportunity to reflect on their work. As a large-scale project involves multiple

personnel, conducting stand-up meetings first at a discipline level and using the discussions of these meetings in the stand-up meeting for multidisciplinary level can be beneficial. Since this would allow the team to have more concurrent discussions concerning the project in a time-bound manner.

Yet, in both cases, the team members need to be attentive to not getting engaged in technical discussions, and therefore there is a need to develop a working procedure for conducting stand-up meetings within the team. Since these procedures can help individuals recognize the objective of conducting stand-up meetings, how the meetings must be conducted and the things that need to be avoided in these meetings.

6) Team bonding sessions

Through the observed communication practices of the team, it was understood that having social interaction with each other improved their team bonding and allowed everyone to get acquainted with each other. The findings also describe that the relationship between two individuals directly impacted the communication they had with each other.

In the case of a large-scale project when the size of the team increases, and new members are added to the team for managing the increase in work. Conducting a few team bonding sessions at the start of the project and during the project can help individuals to familiarise themselves with each other and improve their relationships with others. Since the results indicate that a good relationship between individuals is a prerequisite for improving communication in the team. Conducting these sessions would aid in that cause.

7) Protocols for the usage of emails

The results indicate that sending information through emails certainly allows individuals to keep track of it and allows them to reflect on it at a later stage. But the same results also indicate that exchanging many emails does increase the processing time of information.

With an increase in the size of the project, the number of emails exchanged would also increase. Since a significant exchange of information in the form of contractual agreements and queries related to the project, would be done through emails. To ensure that this information exchanged through emails is processed in time, and the design process continues smoothly, certain protocols regarding the use of email are required as suggested from the analysis of the comparison.

8) Dedicating time for meetings in the project schedule

To overcome the project complexity associated with large projects, the team had increased the frequency of meetings, which was also recommended in the theory. The increased frequency of meetings was beneficial for the team. But it was learnt that the increased frequency of meetings reduced the time available for an individual to work on a task. Thus, for future projects, additional time for conducting meetings can be incorporated into the project schedule. An estimate of this

time can be made based on the number of hours individuals spent in meetings in previous projects, which is recorded in the system. The objective here is to have a high frequency of meetings in a project, but at the same time provide individuals with sufficient time to work on their tasks.

8.2 Validation of recommendations

To validate the recommendations made in the previous step, interviews with two experts working in the design team were conducted. To ensure the correctness of this step and avoid bias, the two individuals selected were different from the individuals who were previously selected for the semi-structured interviews. In this section, the major points discussed concerning each recommendation during the two interviews are described. (Read point 1 as discussion on validation of recommendation 1)

1) Both the experts agreed that this recommendation helps improve communication in the team. The reasoning provided for this by Expert 1 was that developing some guidelines to support communication within the team would help individuals recognise that soft skills like mutual respect are also important.
2) Expert 1 supported this recommendation, but Expert 2 suggested that this recommendation was incomplete. Expert 2 described this recommendation as valuable and can be improved by asking the chair of the meeting to discuss the ideas individuals have posted on an online platform used by the team for brainstorming. Such an activity would ensure that individuals would feel that their suggestions are equally important and are being acted upon.
3) Both the experts were in partial disagreement with this recommendation. Expert 2 suggested that in large-scale projects it was important to involve as many people in meetings as possible, as individuals should be aware of development and decision are taken in a meeting. Whereas, Expert 1, suggested modifying this recommendation based on the lean perspective. Expert 1 suggested that completing a meeting within a given time can make it more efficient, as lengthy discussions in the meeting are avoided.
4) Both the experts agreed with this recommendation, and the justification provided by them was that retrospection can help to learn and being open to feedback can bring benefits to the team. Expert 1 further suggested having HR training on communication every 3-4 years to develop a feedback culture in the team.
5) Both the experts agreed with this recommendation. However, Expert 1 informed that the working procedure for stand-up meetings was not made until now since this was a pilot project for the team. Expert 1 further suggested conducting training sessions on lean, to teach people how to adapt to the new ways of working and embed that in company culture. Whereas Expert 2 suggested placing a poster describing tips & tricks of stand-up meeting in the conference room.

6) For this recommendation also, both the experts agreed. Since they also reiterated that these sessions help to develop a good relationship and a collaborative environment within the team. Additionally, Expert 2 described that in every project there is a lack of budget which restricts them from organising team alignment sessions and doing team-building activities.
7) Expert 2 was in complete agreement with this recommendation. But Expert 1 suggested that this recommendation should not be limited to emails, but it should aim to reduce all forms of digital communication in the team. The justification provided by Expert 1 was that a filter cannot be applied to the other digital communication mediums, and the expectations of individuals wanting an immediate answer to their query cannot be fulfilled.
8) Both the experts acknowledged that this was a good point, and it can be worked out.

8.3 Categorisation of recommendations

Following the development and validation of the recommendations, a scheme is developed to categorise these recommendations. The categorisation of these recommendations is done to highlight a set of recommendations on which the team should place its immediate focus when making a transition from working on a small project to a large project.

The recommendations are categorised based on two parameters; impact, and the time required to implement the recommendation. The impact of the recommendation is calculated based on the count of the activity associated with the recommendation received during the interviews (see **Table 5**). Activities having a count of 7 or above (7 out of 13 interviewees > 50%) are described as high impact recommendations. Whereas the recommendations that can be applied immediately to bring the team on the path of achieving project success are described as short-term change. While the recommendations that will require time to implement are described as long-term changes. This categorisation of recommendations is explained with the help of examples described below and later illustrated through **Figure 11**.

High impact- short term change

Drafting a communication plan should be the priority of the team since this plan would cover all activities related to communication in the team. Consequently, the impact of this recommendation is high. Moreover, as such a plan can be framed in a few days, this recommendation is categorized as a short-term change.

Similarly, the recommendation, providing equal opportunity to everyone in the meeting, is classified under this category. Since this recommendation aims to mitigate the challenge of the build-up of the group in the meeting, which was mentioned by 9 out 13 interviewees (9), this recommendation has a high impact. Besides, this recommendation can be turned into action immediately in the meetings conducted by the team. Thus, it is categorized as a short-term change.

The other recommendation in this category is developing protocols for using emails. As it is used to mitigate the challenge, increased frequency of emails (10).

High impact- long term change

The recommendation, adding a feedback loop in the working procedure, was created to mitigate the challenge, limited feedback (8). Therefore, it has a high impact. However, developing a feedback culture within the team would take time, and thus this recommendation is represented as a long-term change.

Likewise, the recommendation time-bound meeting has a high impact as it is associated with multidisciplinary meetings conducted by the team (11). Yet, it is described as a long-term change as individuals would take time to get adjusted to this type of meeting from the lengthy engineering meetings they have regularly.

The other recommendations in this category are conducting team bonding sessions and dedicating time for meetings to the project schedule. The respective challenges mitigated by these recommendations are bad personal relationships (9) and increased frequency of meetings (10).

Low impact- short term change

Formulating tips & tricks for conducting stand-up meetings have a gentle impact as only 6 members had described that these meetings were not conducted properly. However, it is stated as a short-term change, as only minor modifications are required in the stand-up meetings the has been conducting regularly.

Low impact- long term change

None

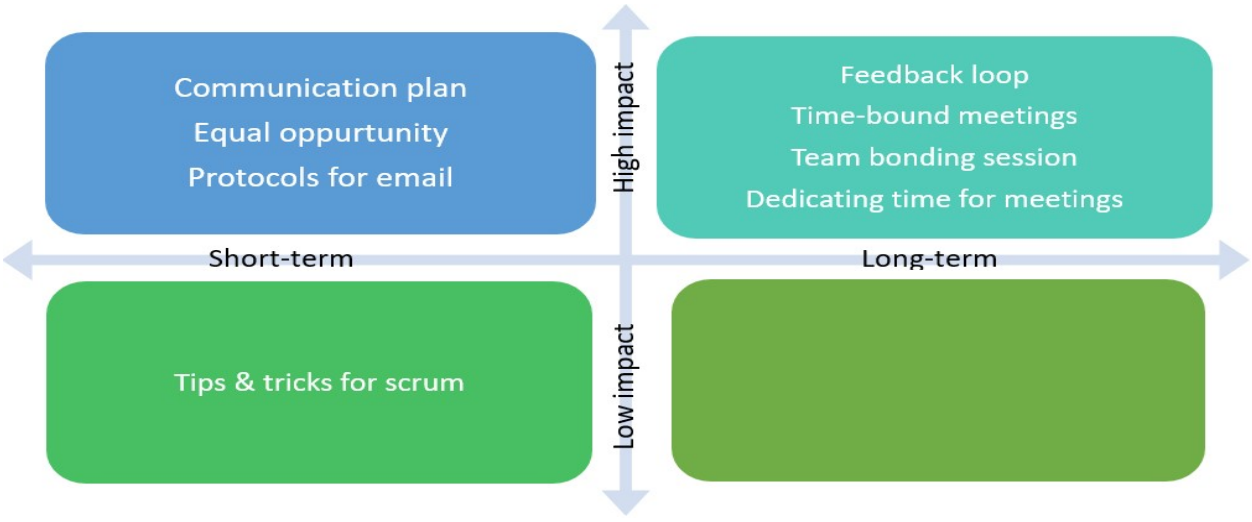

Figure 11: Categorisation of recommendations

8.4 Discussions

In this section, discussions are made to express the theoretical significance of the results obtained for this research and the recommendation framed in previous sections.

Personal relationship

A noticeable result obtained in this research indicates that having open conversations on an individual level helps team members to develop a good relationship with each other, which in turn allows the team to function smoothly. This may demonstrate that for facilitating an easier flow of information within a team, developing, and maintaining a healthy relationship is important (Ning, 2014). Moreover, while construction project teams may be regarded as of a temporary nature, researchers suggest that the network developed by individuals in these project teams serves as a medium of long-term knowledge transfer (Ning, 2014).

Lean

The design stage of a project is very dynamic since it requires the team to have constant discussions and meetings to assess the impact of the decisions made by the team on the final product the team wants to deliver (Owen, Koskela, Henrich, & Codinhoto, 2006). The findings of this study show that a team usually executes such activities through multidisciplinary meetings and stand-up meetings.

However, the recommendations of this research showed that when a team needs to work on a bigger project, adapting lean thinking to organising these meetings is more useful. Since the meetings conducted traditionally take up a lot of time available to the team for a project, and demand the team to put in a lot of effort (Owen, Koskela, Henrich, & Codinhoto, 2006). Whereas, visualising the meetings conducted in the design stage of a project as a process helps to focus on the main objectives the team wants to fulfil for the project from that meeting and minimise the time required for sharing information from one discipline to another (Ballard & Koskela, 1998).

Additionally, the use of lean principles nurtures transparency in the workplace as they tend to increase the practice of sharing updates on information and seeking feedback at regular intervals (Liu Y. , 2018). As seen from the results and recommendation of this research, sharing feedback, and having retrospection can bring benefits to a team working on a complex project in the form of developing a mutual understanding of a task and giving the team a chance to retrospect on the decisions the team has taken. Hence, it could be said that the adoption of lean principles in a project can be another medium through which a feedback culture can be developed in a team.

Groupthink

An obstacle in the way of the team for achieving project success highlighted through the results of this research was the build-up of the group attending a meeting. It was understood that certain individuals would try to dominate the proceedings of the meeting by speaking to push forward their ideas, and every participant in the meeting did not get an equal opportunity to contribute

to the meeting. Researchers suggest that in complex projects when a design team is under time constraints and stress of making a critical decision, such situations can lead to groupthink (Brodbeck & Guillaume, 2015).

Groupthink is described as the phenomenon in which individuals who are opposed to an idea, or a decision do not challenge the group's consensus and instead follow the majority's viewpoint (Brodbeck & Guillaume, 2015). This situation is considered to have a deteriorative impact on the quality of decisions taken by the team, and on the overall growth of the team.

Brodbeck et al., (2015) describe that groupthink leads a team to make poor use of available knowledge and approach a solution for a problem with a process that only certain individuals are comfortable with. This also limits the capability of the team in generating creative solutions for a complex problem. Furthermore, groupthink does not allow the team to create a collective knowledge bank and restricts the team from identifying the hidden potential of individuals. Thus, limiting the growth of the team.

The recommendation developed in this research, providing equal opportunity to individuals in the meeting is a response to this challenge. Since the objective of this recommendation is to mitigate biased discussions and decision-making, by promoting every individual to present his view on the topic which the team is having a discussion.

Summary

This chapter presented the recommendations for practice and the discussions, built on the results obtained for this study. The recommendations were framed to depict the changes a team needs to make in the communication practices followed by the team, for achieving project success while making a transition from working on a small project to a large project. Further, a validation of these recommendations was conducted with two experts, and suitable adjustments were made to the recommendations based on the comments provided by the experts.

Additionally, the recommendations were categorized using two parameters; impact, and the time required to implement the recommendation. The objective of making this categorisation was to enable the team to place its focus on recommendations that would yield immediate results and highlight the recommendations which would help the team to improve in the long run.

Following this, a few discussions built on the results and recommendations for practice developed in this research were presented. These discussions showed that adapting lean principles can bring numerous benefits for a team in the form of bringing focus in the meetings, minimizing transaction time of sharing information, and developing a feedback culture. Also, these discussions described that when working on a complex project, using a recommendation framed in this research, a team can mitigate various challenges associated with groupthink.

9. Conclusion

Why?

This chapter is written to provide the conclusion of this research, which helps the readers of this report understand why this research was conducted.

What?

Through this chapter, the conclusion of this research is described, and the significance of this research is discussed.

How?

By providing a concluding answer to the main question, and highlighting the limitations of this research, future research can be carried out based on the work done in this research, and the practical implications of this study.

9.1 Conclusion

This research started with the agenda of exploring the relationship between communication and project success since communication was described as one of the critical success factors in a team working in the design phase of a project by previous researchers. The purpose of exploring this relationship was to identify the drivers and barriers of communication, through which researchers and practitioners can understand how communication influences a team's changes to achieve project success. The results obtained for this research and the model developed to describe the relationship between the drivers and the barriers of communication with project success in **Chapter 7**, do help to fulfil the aim and purpose of conducting this research.

Further, to conclude this research an answer to the sub-questions and the main question of this research are provided.

SQ 1: How does communication relate to project success?

The results of this research indicate that the definition of project success for a team developing a design for a project is not just limited to meeting the criteria of scope, time, and quality. Project success for a team also means having a good collaborative environment, and proper coordination in the team. And the results of this research show that effective communication practices within a team allow it to perform well on all these criteria of project success.

First, having face-to-face communication and social interaction with team members allows individuals to become familiarised and develop a good bond with each other, which is crucial for them to work together as a team. Second, communication is the means through which individuals can coordinate the interfaces between their work and ensure that their work is compatible. Third,

communication in the form of discussion and feedback enables a team to develop the best technical solution for a given condition and improve the quality of the design. Fourth, increased frequency of communication allows a team to reflect and develop on their work and enables the team to overcome complexity associated with the project such as tight schedule or high interdependence among tasks.

Thus, it is understood that communication is directly related to the probability of a team achieving project success.

SQ 2: How does a design team practice communication?

The answer to this question is provided by a twofold investigation carried out in this research. First, the communication practice of a design team is guided by the documents prepared by the team, which describe the procedures individuals should follow while communicating with each other in the team. These procedures are projected communication matrix, project execution plan, work instructions, communication plan and document management system. The purpose of creating these documents is to give the communication in the team a structure, through which individuals know their roles, responsibilities, and desired results for a project by communicating with each other.

Apart from this, individuals in a design team also practice communication following their own convention. Communication practices followed by these individuals include having face-to-face communication to share feedback, conducting stand-up meetings for having quick discussions regarding project progress and chatting via the in-built function of modelling software to resolve clashes in the design. Following such practices allows the team to develop collaboration and realise the desired results. Nevertheless, having a few communication practices like extrovert people dominating the meeting, exchanging a high volume of emails, and not communicating with each other due to bad relationships, damages the work environment and the chances of the team to realise the desired results.

SQ 3: What are the barriers and drivers of communication?

The drivers of communication are defined as the communication practices which enable a team to achieve project success. Similarly, the barrier of communication is the communication practice that limit a team to achieve project success.

The drivers of communication found through this research are *feedback, multidisciplinary interaction, social interaction, stand-up meetings,* and *increased frequency of communication*. Sharing feedback helps individuals in a design team develop a shared understanding of a task, whereas multidisciplinary interactions help develop the best technical solutions for a project. Likewise, having social interactions within the team helps people build a good working

relationship with each other, and holding stand-up meetings allows the team to have quick discussions on how to make progress in the project. Finally, increased frequency of communication allows a team to reflect and develop on their work and empowers the team to manage a tight project schedule.

The barriers of communication found through this research are *reduced face-to-face communication, build-up of participants in a meeting, large group size, high frequency of emails, and high frequency of meetings*. Reduced face-to-face communication creates a lack of trust between individuals while having many participants in a meeting provides limited opportunity for individuals to actively participate. Moreover, while holding a meeting, it is important to ensure that everyone gets equal opportunity to speak and contribute, else it would cause some individuals to dominate the meeting and steer the project. Besides, exchanging a large number of emails reduces the processing speed of information and having a high frequency of meetings reduces the time available for people to work on their tasks.

MQ: How can improving the communication practice of a design team help it to achieve project success?

The results and discussion of this study suggest that communication plays a crucial role in a project since communication can improve the activities that a team performs to achieve project success. However, at the same time, communication, if not done correctly, has the potential to serve as a barrier to project success.

Through this research, it was understood that, when working on a project, a team practices communication in the form of individual conversations, group discussions, and the exchange of emails. The objective of the team for communication through these various means of communication is to manage the interfaces, schedule, and quality of the project. Comparing and combining theoretical and empirical findings showed that these communication practices help the team achieve project success in several ways.

First, having face-to-face communication allows individuals to develop a good relationship and understanding expectations and execution of a task. The result of a good relationship is the development of a collaborative workspace, while developing a mutual understanding for a task helps the team to minimize rework and avoid time delays. Second, the multidisciplinary meetings and group discussions conducted by the team are a source through which the team analyses complex problems with the project and develop creative solutions for solving them. Moreover, these meetings are the medium through which the team manages the interfaces between various disciplines, has a reflection on the overall work done by the team, and decides on the steps the team needs to take to keep the project schedule and the budget in check.

However, the results of this research show that a team encounters certain challenges while performing these activities. These challenges are reduced face-to-face communication, build-up

of participants in a meeting, high frequency of emails, and high frequency of meetings. The consequent limitations created by these obstacles for the team in achieving project success are lack of trust, project steering, increased processing time of information and reduced time available for individuals to work on their tasks.

To resolve these challenges, a few recommendations were framed in this research to improve the team's communication practices and help it achieve project success. These recommendations described that improving communication practice of the team in terms of sharing feedback, giving an equal opportunity to everyone to contribute to the meeting, developing protocols for use of emails, and describing tips & tricks of conducting stand-up meetings can help the team in a significant manner. With these recommendations, the team can align expectations from a task, avoid biased discussions and solutions generated by groupthink, ensure a smooth flow of information, and have focused stand-up meetings.

To conclude, communication can be said to be the key to achieving project success and improving the communication practices of a design team with the help of the recommendations framed in this research would allow the team to achieve success in the project.

9.2 Limitation of research

The model developed to describe the relationship between communication and project success was based on studying the literature of team communication and observing the communication practices of a particular team working in the design phase of a project. Thus, this model does not cover the drivers and barriers of communication in the project, for the communication a team has with the client, vendors, or government agencies. Also, when multiple companies are involved in developing a project's design, as in the case of a joint venture, this model may not be adaptable directly. This is due to the difference in the communication practice followed by different companies and the communication practice the company wants to adopt to manage a joint venture project.

Likewise, the professionals interviewed as a part of this research were engineers who worked in the design phase of the project at a common location. Therefore, this model did not cover the best practices and challenges individually during the construction phase of a project. Working in a common place presents more opportunities for a person to have face-to-face communication as individuals are near each other. Whereas individuals are scattered over various places on a construction site, the possibility to have frequent face-to-face communication is reduced.

This research was conducted in the Netherlands, and all the professionals working in the team were residing in the Netherlands. So, first, no communication practices related with cultural differences within the team were observed. Second, the changes a team must make to its communication practices to overcome time zone differences or language barriers were not noticed.

9.3 Recommendation for future research

The methodology adopted and the attributes of communication defined in this research for investigating the relationship between communication and project success can be used as a template by academic researchers who wish to find drivers and barriers of communication in a team during the construction phase of a project. Similarly, this work can be expanded to encompass drivers and barriers of communication between stakeholders of a project. The research question that can be used in this case can be: "*How can improvements in the communication practice of stakeholders help them achieve project success?"*

Since this research did not study the effect of cultural and language differences on communication practices adopted by a team, future research can investigate how the various communication mediums should be used to mitigate the challenges associated with communication across cultures and languages. Thus, this can be translated into the following research question that can be used here is: "*How can the different communication mediums be used to mitigate the cultural and languages barriers associated with communication?*"

The aspect of using 3D modelling software (BIM) as a means of communication was briefly touched upon in this research. Future research can focus on how a person can discuss and share information in real-time with individuals and agencies who do not have access to BIM and thus reduce the need to share drawings and images through other means of communication such as emails. The focus of such research can be on investigating if BIM is a better medium to discuss a design with a non-technical person when compared with 2D drawings and images. The research question that can be used here is: *"To what extent does the use of BIM provide a better understanding of a design to a person when compared with 2D drawings?"*

9.4 Recommendation for Tebodin

The documents reviewed, and the communication practices observed by conducting semi-structured interviews is the data that belongs to Tebodin. Thus, the analysis and the results obtained for this research reflect how individuals within the organization perceive the need to improve communication practices within the company.

This study shows that there are various communication practices followed within Tebodin which enable it to achieve good project results every year. Besides, this study also shows that certain communication practices limit the company from achieving the desired results. But the recommendations made in this report (**Section 8.3**) would benefit Tebodin to take the first step in the direction of improving communication within the organization, achieve the desired results from the project, and grow as an organization.

As mentioned in the section on the limitation of this research, this research only covers the communication of a team in the design phase of a project. Therefore, a similar study within the organization aimed at improving communication practices during the construction phase of a

project can assist the company to improve its chance of achieving project success in that phase as well.

Finally, the individuals who participated in the semi-structured interview of this study were from just two of the many offices Bilfinger Tebodin has in the Netherlands as well as other parts of Europe. Conducting a small survey on how communication practices with the company can be improved would help the company to get more insights and frame more standard protocols regarding communication.

9.5 Personal reflection

This experience of doing a thesis was like a rollercoaster ride for me, as the past few months I have spent on this research have been filled with several ups and downs. But like at the end of a rollercoaster ride, the whole experience feels nice and has a happy ending for me.

At the start of this thesis, the notion I had about doing research was it can be done within three to four months, as a researcher just has to select a topic, develop a research question, and solve it using literature and experiments. But only when I started researching by myself, I realised that it is much more complex and time-consuming than I had initially assumed it to be.

Now when I reflect on the things that I could have done better during my research, the first thing would be to start with a concise research area and research questions. Having a broad topic and obscure research questions at the start did not allow me to develop concrete arguments for the research work I did initially. Moreover, I was late in identifying the potential of maintaining a research diary, and only a few months before the completion of my research I realised how instrumental a research diary is for gathering thoughts on research and reflecting on them later.

In the recommendation I propose for the use of a team in a project (**Section 8.3**), there are three recommendations I used in my research, having face-to-face communication over sending emails, having an increased frequency of communication, and seeking feedback. In the weekly meetings I had with all the supervisors on an individual level, I could incorporate these recommendations, and based on my experience, these practices are really helpful.

The biggest takeaway for me from this research came from the interactions I had with various professionals during the interviews I conducted for my research. These interviews not only provided me with data for my research but also allowed me to grasp a certain portion of the experience of these professionals in managing a project.

I believe that the learnings, and the experience from this research, along with the recommendations of this research, would allow me to communicate in a subtle but potent manner with the people I would be working in a project team when I start my professional career.

References

Adams, W. (2015). Conducting semi-structured interviews. In J. Wholey, H. Hatry, & K. Newcomer, *Handbook of practical program evaluation* (4th ed., pp. 492-505). Jossey-Bass. doi:10.1002/9781119171386.ch19

Ballard, G., & Koskela, L. (1998). On the agenda of design management research. *In Proceedings of the 6th annual conference of the International Group for Lean Construction*, (pp. 52-69).

Brodbeck, F., & Guillaume, Y. (2015). Effective Decision Making and Problem Solving in Projects. In M. Wastian, L. von Rosenstiel, M. West, & I. Braumandl, *Applied Psychology for Project Managers* (1st ed.). Berlin, Heidelberg: Springer. Retrieved from https://doi.org/10.1007/978-3-662-44214-2_3

Chametzky, B. (2016). Coding in Classic Grounded Theory: I've Done an Interview; Now What? *Sociology Mind*(6), 163-172. doi:10.4236/sm.2016.64014

Cheung, S. O., Yiu, T. W., & Lam, M. C. (2013). Interweaving Trust and Communication with Project Performance. *Journal of Construction Engineering and Management, 139*(8), 941-950. doi:10.1061/(ASCE)CO.1943-7862.0000681

Chiu, M.-L. (2002). An organizational view of design communication in design collaboration. *Design Studies, 23*(2), 187-210. Retrieved from https://doi.org/10.1016/S0142-694X(01)00019-9

Dainty, A., Moore, D., & Murray, M. (2006). *Communication in construction : theory and practice* (1st ed.). Taylor & Francis e-Library.

Emmitt, S., & Gorse, C. A. (2003). *Construction Communication.* Blackwell Publication Limited.

Fink, A. (2014). *Conducting research literature reviews: from the internet to paper* (4th ed.). SAGE Publications, Inc.

Jha, K., & Iyer, K. (2006). Critical factors affecting quality performance in construction projects. *Total Quality Management, 17*(9), 1155-1170. doi:DOI: 10.1080/14783360600750444

Kamalirad, S., Kermanshachi, S., Shane, J., & Anderson, S. (2017). Assessment of construction projects' impact on internal communication of primary stakeholders in complex projects. *6th CSCE International Construction Specialty Conference.* Vancouver, Canada.

Kwofie, T. E., Aigbavboa, C., & Thwala, W. (2020). Nature of barriers in construction communication performance. In *Effective Construction Project Delivery* (pp. 73-82). Springer, Cham. Retrieved from https://doi.org/10.1007/978-3-030-49374-5_6

Liu, Y. (2018). *Scrum in construction industry to improve project performance in design phase.* http://digitalcommons.harrisburgu.edu/pmgt_dandt/31.

Liu, Y., Baldwin, N. R., & Shen, L. Y. (2006). Identification of factors influencing communication between participants in construction projects. *The CRIOCM 2006 International Symposium on Advancement of Construction Management and Real Estate.* Building and Real Estate Dept. of, the Hong Kong Polytechnic Univ., Kowloon, Hong Kong, China.

Marlowa, S., Lacerenzab, C., Paolettia, J., Burke, S., & Salas, E. (2018). Does team communication represent a one-size-fits-all approach?: A metaanalysis of team communication and performance. *Organizational Behavior and Human Decision Processes, 144*, 145-170. Retrieved from http://dx.doi.org/10.1016/j.obhdp.2017.08.001

Mavuso, N., & Agumba, J. (2016). Factors of communication management for successful project delivery in the Swaziland construction industry. *9th Annual Quantity Surveying Research Conference.* Port Elizabeth.

Nguyen, L., Ogunlana, S., & Lan, D. (2004). A study on project success factors in large construction projects in Vietnam. *Engineering, Construction and Architectural Management, 11*(6), 404-413. doi:DOI 10.1108/09699980410570166

Ning, Y. (2014). Quantitative effects of drivers and barriers on networking strategies in public construction projects. *International Journal of Project Management, 32*, 286-297. Retrieved from http://dx.doi.org/10.1016/j.ijproman.2013.04.003

Nipa, T., Kermanshachi, S., & Kamalirad, S. (2019). Development of effective communication framework using confirmatory factor analysis technique. *ASCE International Conference on Computing in Civil Engineering* (pp. 580-588). Atlanta, Georgia: ASCE. doi:https://doi.org/10.1061/9780784482438.073

Oke, A., & Idiagbon-Oke, M. (2010). Communication channels, innovation tasks and NPD project outcomes in innovation-driven horizontal networks. *Journal of Operations Management, 28*, 442–453. doi:10.1016/j.jom.2010.01.004

Otter, A. d., & Emmitt, S. (2007). Exploring effectiveness of team communication: Balancing synchronous and asynchronous communication in design teams. *Engineering, Construction and Architectural Management, 14*(5), 408-419. doi:10.1108/09699980710780728

Otter, A., & Emmitt, S. (2008). Design team communication and design task complexity: The preference for dialogues. *Architectural Engineering and Design Management, 4*(2), 121-129. doi:10.3763/aedm.2008.0072

Owen, R., Koskela, L., Henrich, G., & Codinhoto, R. (2006). *Is agile project management applicable to construction?* Salford Centre for Research and Innovation (SCRI), University of Salford. Retrieved from http://usir.salford.ac.uk/9369/

Patrashkova-Volzdoska, R. R., McComb, S. A., Green, S. G., & Compton, D. W. (2003). Examining a curvilinear relationship between communication frequency and team performance in

cross-functional project teams. *IEEE Transactions on Engineering Management, 50*(3), 262 - 269. doi:10.1109/TEM.2003.817298

Safapour, E., Kermanshachi, S., Kamalirad, S., & Tran, D. (2019). Identifying effective project-based communication indicators within primary and secondary stakeholders in construction projects. *Journal of Legal Affairs and Dispute Resolution in Engineering and Construction, 11*(4). doi:10.1061/(ASCE)LA.1943-4170.0000332

Santalova, M. S., Lesnikova, E. P., Nechaeva, S. N., Borshcheva, A. V., & Charykova, O. G. (2019). Information hindrances and communication barriers in project interactions. *International Conference Project 2018: The Future of the Global Financial System: Downfall or Harmony. 57*, pp. 273-281. Springer, Cham. Retrieved from https://doi.org/10.1007/978-3-030-00102-5_29

Scott-Young, C., & Samson, D. (2008). Project success and project team management: Evidence from capital projects in the process industries. *Journal of Operations Management, 26*(6), 749-766. doi:https://doi.org/10.1016/j.jom.2007.10.006

Senescu, R., Aranda-Mena, G., & Haymaker, J. (2013). Relationships between project complexity and communication. *Journal of Management in Engineering, 29*(2), 183-197. Retrieved from https://doi.org/10.1061/(ASCE)ME.1943-5479.0000121

Tai, S., Wang, Y., & Anumba, C. J. (2009). A survey on communications in large-scale construction projects in China. *Engineering, Construction and Architectural Management, 16*(2), 136-149. doi:10.1108/09699980910938019

Thomas, S. R., Tucker, R. L., & Kelly, W. R. (1998). Critical communications variables. *Journal of Construction Engineering and Management, 124*(1). Retrieved from https://doi.org/10.1061/(ASCE)0733-9364(1998)124:1(58)

Tran, D. Q., Nguyen, L. D., & Faught, A. (2017). Examination of communication processes in design-build project delivery in building construction. *Engineering, Construction and Architectural Management, 24*(6), 1319-1336. doi:10.1108/ECAM-12-2015-0192

Xie, X., Thorpe, T., & Baldwin, A. (2000). A survey of communication issues in construction. *Akintoye, A (Ed.), 16th Annual ARCOM Conference. 2*, pp. 771-80. Glasgow Caledonian University: Association of Researchers in Construction Management.

Appendix A: Procedure for literature review

The following section describes the procedure that has been adopted to find the relevant literature from various sources available that will help in answering the sub-questions framed for this research work.

For conducting a literature review for this study, the book written by Fink (2014) was used as a guide. In this book, Fink (2014), explains the various steps in detail research should follow while performing a literature review for his study and points out certain points that should not be neglected while performing this procedure.

A literature review conducted for a study is a structured procedure used for assessing, reviewing, and consolidating the literary works that have been finalized and documented by academics, and researchers previously (Fink, 2014). This procedure consists of seven steps, and these steps are explained in detail with the help of how they are used in the context of this research.

1. Selection of research questions

Research always commences by formulating a research question. The formulation of this question is important as it drives the study. The research question for this study had been formulated in **Section 2.3**, and the reasoning for formulating it has been provided earlier in this study.

2. Selection of database

A source where various papers, textbooks, and documents are compiled is called a database. Through data provided in this database, the researcher will address issues discussed or find solutions to the research questions. For this research different online databases were used that could provide data on team communication practices and management. The list of the database is described in **Figure 12**.

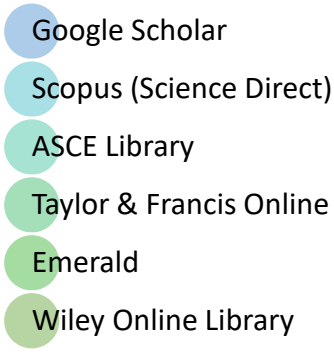

Figure 12: List of the database used in the research

3. Determining specific keywords

The keywords are terms that are employed to find scholarly publications and documents from the database. These keywords are built on the terms that are used to construct the research question, i.e., these terms are extracted from the research question. For this research since four different sub-questions were framed, out of which answers to three sub-questions were to be found via the literature, different keywords were used for each question. The purpose of using a distinct set of keywords for reviewing the literature was that each sub-question was based on a different principle of team communication or represented a different dimension for team communication.

Moreover, synonyms of the selected keywords such as 'elements,' 'factors' for 'attributes,' and likewise for other keywords in combination with Boolean operators were used in this research. **Figure 13** explains how different keywords were extracted from the sub-questions for this research.

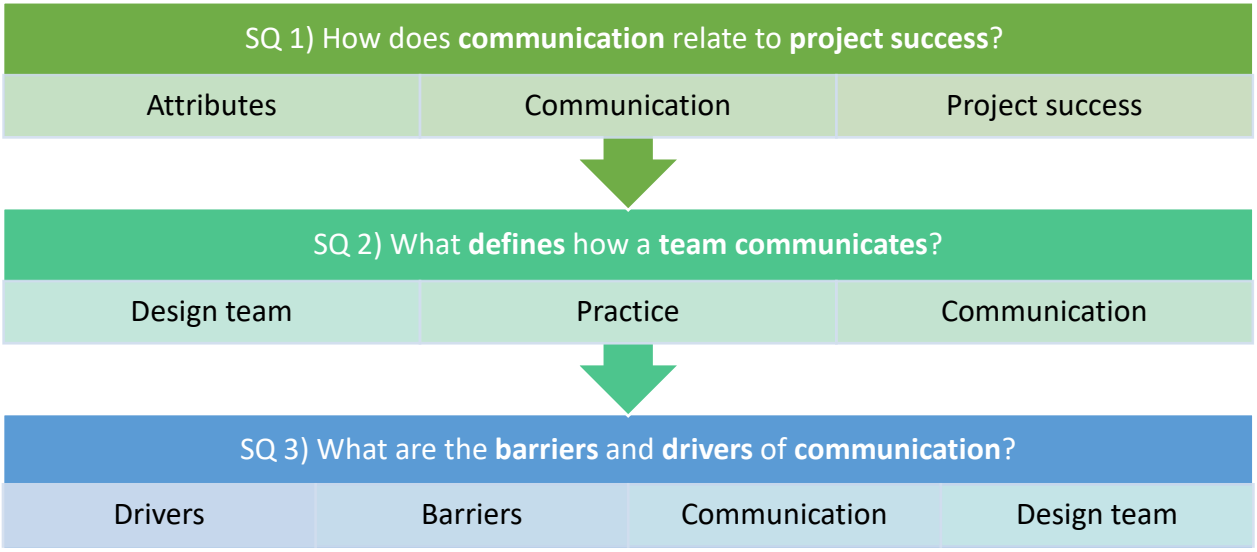

Figure 13: Extraction of keywords from sub-questions for literature search

4. Application of pragmatic parameters for scanning

The next step in the literature review of research is the application of pragmatic parameters for scanning the results obtained after using the keywords to search the database. Numerous publications were found during the initial database search, and yet only some were appropriate for this study. The parameters used to exclude the non-relevant literature were language, sector of study and phase of the project. Here literature published in the English language that related to design teams of construction or an infrastructure project working in the design phase or initial phase of a project were only considered. Thus, publications in other languages or related to other sectors such as IT, or even studies related to team communication in a construction phase of a

project were excluded. In this research literature that was mostly available in pdf format was used. The restriction on the timeframe of publication was limited to studies published until 25 years ago from the time this research commenced, i.e., 1995-2020.

Table 11: Pragmatic parameters for filtering database

Sub-question	Initial search result without application of exclusion criterions	The number after application of various criterions
1	1490	26
2	2150	39
3	1770	33

5. Application of methodological parameters for scanning

In this step, the output received from the previous step is further filtered based on the methodological parameters such as the data collection and analysis method used, number of citations of the selected paper, results of the research obtained. Here the focus was on the studies that could provide qualitative data for the sub-questions, and the results of which provided a clear description of the concept of team communication been considered in that study. The parameter 'number of citations' was used by the researcher to exclude literary work that had only been cited by 3 or less, as the researcher expected these studies do not provide arguments and facts of good scientific quality as they were not cited by many researchers for their work.

Table 12: Filtration of database using methodological parameters

Sub-question	The number after application of various criterions	The final number after application of various criterions
1	26	10
2	39	15
3	33	9

6. Conducting a literature review

Following the selection of different literary works based on different shortlisting parameters, finally, the literature is reviewed to find the answers for the sub-questions.

7. Assimilation of the results

This step relates to understanding the information retrieved from the various sources during the literature review, processing this information and utilizing it to elaborate on the diverse topics discussed in the research. This step has been performed and is documented through **Chapter 3** in this report.

Appendix B: Sample interview questionnaire

1) Greetings, how are you?
2) I would like to introduce myself and explain the purpose for which I am having this meeting with you, can I?
3) Mr X had asked me to contact you, but he did not tell me about your role in the team. Can you explain to me more about your role in the team?
4) What is the first thing that comes to your mind when you hear about the topic that I would like to discuss with you in today's meeting?
5) Based on your experience with the team, can you let me know how having face-to-face communication helps the team?
6) What are the critical aspects that we should focus on if we want to improve these face-to-face communications in the team?
7) How frequently do you have meetings within your discipline and with other disciplines?
8) Can you tell me about the aspects that are important for ensuring that these meetings function effectively and produce the desired results?
9) Looking at your company, how do you think the quality of work the company wants to deliver is influenced when these meetings do not function properly?
10) What is your thought on the use of emails for project communication? How helpful are these emails?
11) Are you aware of scrum or the agile way of working?
12) From your perspective, is the scrum way of organizing communication within the team working properly? What kind of benefits and disadvantages do you see in it?
13) Since you have had a long journey in this field, what approach would you suggest fixing the communication issues within the team that you have experienced?
14) Can you summarize the whole interview for me?
15) Can you suggest to me the name of your colleague with whom I can have a similar talk?
16) To conclude this interview, I would like you to give me your suggestions that through which I can improve these interviews.