Effects of Diversity on the Social Structure of a Project Team

MSc thesis

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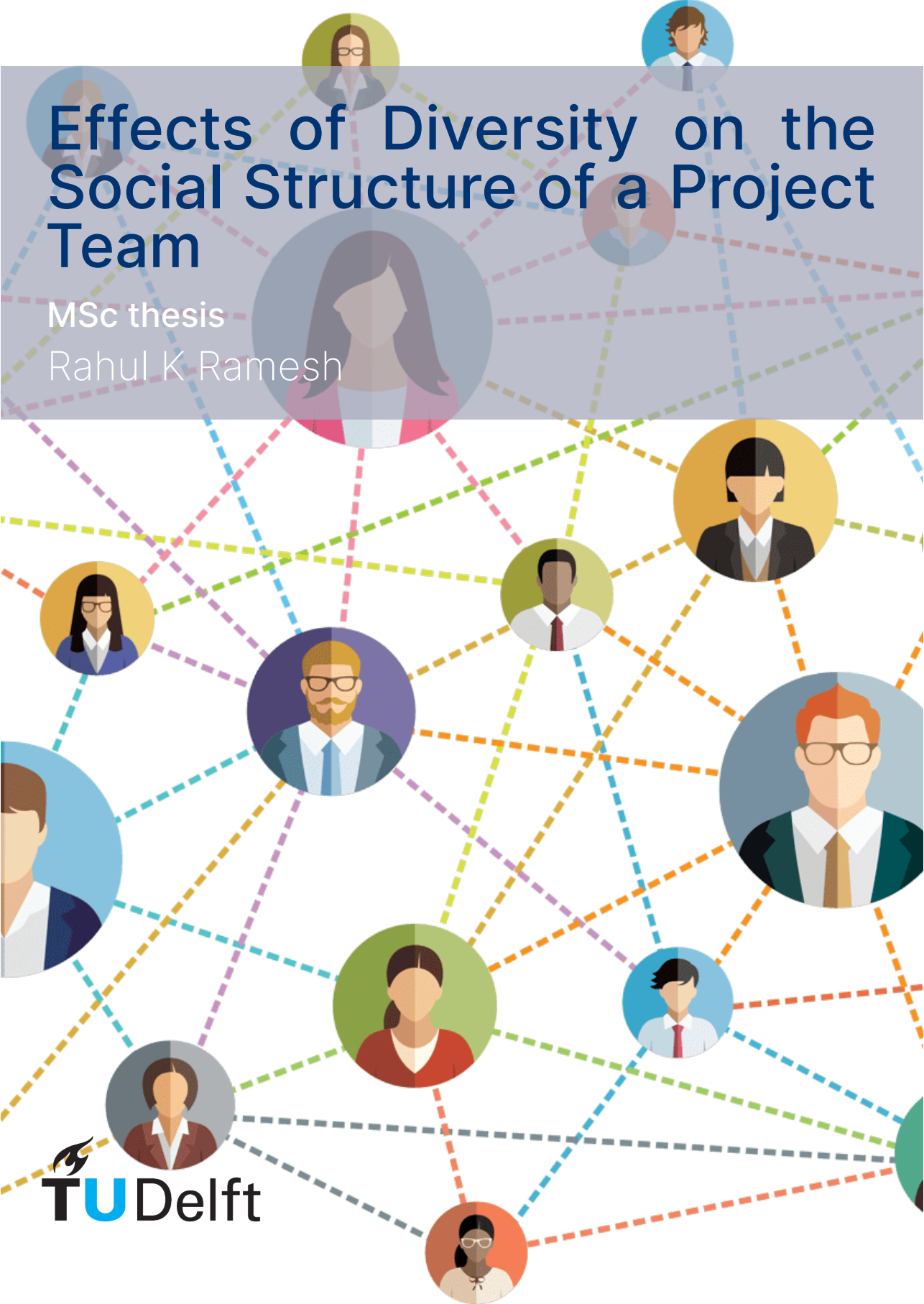

TU Delft

EFFECTS OF DIVERSITY ON THE SOCIAL STRUCTURE OF A PROJECT TEAM

by

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Life before death, strength before weakness,
journey before destination

PREFACE

This graduation thesis marks the final step of my journey towards the Master of Science degree in Construction Management and Engineering at TU Delft. Looking back at the past three years, I am humbled and grateful for the transformative journey I have undertaken in my personal and professional life. It has been a remarkable period, marked by moments of triumph and challenges, which have shaped me into the person I am today.

I am deeply grateful to my supervisors, Dr. ir. Marian Bosch Rekveldt and Ir. Anastasia Kyriakou, for their unwavering support and patience throughout my research journey. Their invaluable guidance has been instrumental in overcoming challenges and navigating the research process. I extend my heartfelt appreciation to Prof. Dr. Hans Bakker, my graduation chair, for his dedication in pushing me to higher standards of writing and presenting my research. His emphasis on clarity and precision has guided me effectively. I am sincerely thankful to Dr. Robert Verburg for his guidance at the start of this thesis in defining the boundaries of my study and his feedback during the greenlight phase, shaping the direction of my work. I express my gratitude to Jan Reinout Deketh for his support in identifying the teams to be studied and for providing valuable expert insights.

To my incredible family in Delft, including the Derry Cherry Group (Srijit, Kanhai, Rohan, and Vivian), the CME Group (Mehna, Zach, Barsha, Vikas, Aditya, Karan, and Adhil), and the Leeghwaterstraat boys (Prateek, Divvay, Kaushik, and Raghav), I am immensely grateful. You have provided me with a home away from home and made the last three years an unforgettable journey. Thank you for making Delft a place filled with love, warmth, and a sense of belonging. I am immensely grateful to Ivana, your presence has been an absolute blessing, becoming an extraordinary pillar of strength on whom I can always wholeheartedly depend on. I would like to thank Kairasi, your presence in my life has been a source of strength and inspiration, I am truly blessed to have you by my side.

Lastly, I would like to thank my family - Achan, Amma and Pooja - for your unwavering support and guidance throughout my life. You have been the unyielding rock behind me, ensuring I never face any difficulties alone. Your sacrifices, both seen and unseen, have paved the way for my success. You have tirelessly nurtured my dreams, providing unwavering encouragement, guidance, and wisdom. Your steadfast belief in my potential has fueled my ambition and pushed me to strive for greatness. I hope you enjoy reading!

Rahul Ramesh
Delft, June 2023

SUMMARY

Using an exploratory approach, this research delves into the intricate interplay between diversity and team dynamics, using social network analysis as a powerful tool. By combining theoretical insights from literature with comprehensive network analysis, we uncover the influence of diversity on power, influence and communication on construction project teams. To accomplish this, a research question is formulated as follows:

"What are the effects of diversity on the social structure of a construction project team?"

The initial phase of the research involves a literature review on diversity, to develop an understanding of diversity within project teams. A preliminary survey collects data on diversity within two project teams and gathers relationship information based on Cross's (2004) four dimensions: frequency, responsiveness, effectiveness, and energy. This empirical data, along with social network analysis (SNA) metrics such as centrality, centralisation, density, clustering, and homophily, provides insights into the manifestation of diversity and its impact on team dynamics. The research findings and conclusions are presented to two experts in the field to enhance the understanding of diversity effects and obtain valuable recommendations. Engaging with these experts aims to deepen knowledge and find ways to mitigate the potential adverse effects of diversity and thus leverage the positive effects of diverse project teams.

The literature review helped create a list of relevant diversity dimensions, which served as the basis for the initial definition of diversity in the literature. Age, gender, language, and nationality are important personal traits, while educational background, functional background, experience, and team tenure are critical job-related traits. In addition, three parameters were integrated into the analysis to understand some of the observed network properties of the investigated project teams. These parameters include organisation, office location, and department.

The findings of this research highlight the significant impact of age, experience, education, functional background, nationality, and gender on team dynamics and collaboration within diverse teams. Age and experience were found to influence the closeness of team members, with younger and less experienced individuals being less connected to the larger network, particularly in relation to older team members aged 50 and above. In consultancy-based work or projects involving experts, higher educational degrees were associated with increased power, influence, and communication within the team. However, this trend was not observed in project management-based teams, where educational degree had minimal effect on an individual's importance to the team.

The tendency to associate with others who share similar characteristics was evident based on nationality, with team members exhibiting a higher affinity to form connections towards individuals from their own nationality. Gender also influenced this effect, although to a lesser extent compared to nationality. Clustering based on nationality, gender, and functional background was observed, indicating that individuals tended to form sub-groups within the team based on these characteristics.

Onboarding and extracurricular activities emerged as factors responsible for the visibility of the effects of diversity within project teams. A comparison between the two teams revealed that the team where deliberate efforts were made to foster bonds among members exhibited lower variations in diversity-related network characteristics. This underscores the importance of effective onboarding processes prioritising trust-building, team integration, and establishing a cohesive unit.

To enhance collaboration within diverse teams, several strategies are recommended based on these findings. Firstly, organisations should focus on implementing effective onboarding processes that emphasise trust-building, team bonding, and the integration of new members. Embracing diversity and inclusivity is important, and efforts should be directed towards fostering collaboration among team members from different backgrounds, valuing diverse perspectives, and ensuring equal access to information to prevent the isolation of specific sub-groups.

Encouraging interdisciplinary collaboration, especially in expert-based work, can enhance problem-solving approaches and the quality of expert solutions. Addressing cultural and language barriers is also essential, as even awareness alone can significantly improve team communication. Providing support and resources such as language training and promoting an inclusive culture can further enhance collaboration.

Moreover, it is crucial to consider the formal organisational structure and strive for inclusivity, equitable distribution of power and influence, and reducing marginalisation. By addressing these aspects, organisations can create an environment that leverages the benefits of diversity, and ultimately improves team collaboration.

In summary, this research underscores the importance of understanding the various factors that influence the social structure within diverse teams. By implementing the strategies and recommendations outlined, organisations can create a more inclusive and collaborative environment, leading to improved team outcomes.

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INTRODUCTION

Project management is the discipline of initiating, planning, managing, and delivering specific projects in order to meet their objectives on time and on budget (PMI, 2021). The emphasis of project management has historically been on the hard skills thought required for project management, pushing soft talents to the margins (Robles, 2012). Even now, such an approach has not changed considerably, with the focus being mostly on the transmission of hard ideas such as technical knowledge, scientific management principles, the use of tools, and concrete deliverables (Jena & Satpathy, 2017). In this age of globalisation, there is an increasing demand for innovative project solutions that embrace technological advances and a focus on soft skills to improve collaboration, which requires a more flexible project management approach (Mckinsey & Company, 2020). Aspects such as communication, people management, personality, leadership, motivation, conflict management, trust-building, adaptability, critical thinking, decision-making, problem-solving, coaching, and team-building are some important features of soft skills that are crucial for project managers.

1.1. CONTEXT

Projects are becoming larger and more complex in almost every region of the world. As a result, the construction and engineering industries are pushing boundaries to combine 'tried and tested' design and construction techniques with innovative design, technologies, and materials to adapt and respond to the ever-changing project landscapes (Buhler, 2017). Because of the ramifications of this change in the construction industry, team diversity has received increased attention in project management during the previous few decades. Research indicates that diverse project teams can leverage a broad spectrum of perspectives contributed by their members (Iles & Kaur Hayers, 1997). Diversity within these teams has been found to enhance both productivity and the overall quality of work conducted within organisations, as supported by empirical studies (Baker & Irvine, 1995). However, diversity in project teams can also bring about unique challenges in the form of conflicts, communication barriers, lack of cohesion etc., within

the social structure of the team (Wu et al., 2019a; Yadav & Lenka, 2020).

Within a construction project, multiple temporary teams are formed, including the owner, contractor, subcontractor, designer, consultant, and supervisor. These teams are diverse in terms of cultural origins, expertise, values, skills, and professional experiences. Recognising the significance of diversity within teams, it becomes evident that this can greatly influence how a construction project team functions. Moreover, since such teams are formed temporarily and disbanded quickly in the context of construction projects, the negative effects stemming from diversity must be addressed swiftly.

The formal organisational structure plays an important role in the social structure of a project team by defining the roles and responsibilities of team members and establishing communication channels (Hunter et al., 2020). In addition to formal team structures that establish an explicit chain of authority and workflows, an underlying informal structure within teams significantly influences the team's social dynamics and interactions (Hunter et al., 2020). These informal relationships, though initially inconspicuous, often dictate the team's functioning (Charles Kadushin, 2012). The presence of diversity within a project team can impact the formation and composition of such informal social networks (Tröster et al., 2014).

The existing methodologies of studying diversity in project teams predominantly rely on qualitative approaches, which can be relatively slow and time-consuming (Patrício & Franco, 2022; Urionabarrenetxea et al., 2021; Wu et al., 2019a). Gathering and analysing qualitative data may thus not align well with the fast-paced nature of construction project environments. A viable alternative to such qualitative methods is the use of quantitative methods that can be quicker.

One promising approach to quantitatively studying diversity in project teams is using social network analysis. In the past, analysing and visualising the effects of changes, such as the inclusion of diversity, on project management teams and systems proved challenging due to the lack of appropriate methodologies (Gardiner et al., 2022). Traditional methods failed to capture the intricate network of links and their functions within the construction process, characterised by task dependencies, structural elements, and process mapping. To understand large interdependent systems in construction, it is essential to grasp the diverse network topologies in which project participants are interconnected (X. J. Zhang et al., 2019). This understanding enables us to comprehend the nature of relationships and the environmental factors that influence individual actors' behaviours, ultimately impacting establishing, developing, and degrading network links - crucial determinants of how collaboration unfolds in a team (Pryke, 2012).

Organisations often analyse recruiting, attrition, promotion, and staff composition metrics to assess the effectiveness of diversity and inclusion activities. While these numbers offer valuable insights, they do not provide a holistic view (Yamkovenko & Tavares, 2017). Social network analysis can offer powerful visual representations of how diversity

truly unfolds within organisations, allowing for a deeper understanding of the impacts of diversity on the social structure of project teams.

1.2. RESEARCH GAP

It is clear from the Section 1.1 that there is a benefit in exploring the effects of team diversity on the social structure of project teams. Through social network analysis, a comprehensive examination of the implications of diversity on collaboration within the project team and the strategies to manage diversity more effectively can be achieved. Such insights will prove invaluable in navigating the evolving landscape of construction project teams.

1.3. RESEARCH QUESTIONS

The main research question is as follows:

'What are the effects of diversity on the social structure of construction project teams?'

The main aim of this research is to quantify the effects of diversity on the social structure of a project team using social network analysis. This result will be achieved by answering four sub-questions, each of which will tackle a specific aspect of the main research question. Chapter 3 gives a detailed research approach that will be followed throughout this thesis. The specific focus of each one of the sub-questions is described as follows:

Sub-question 1: What is diversity in teams from a theoretical perspective?

This sub-question aims to identify the characteristics of the diversity dimensions within construction project teams. The literature study describes the unique circumstances that lead to increased diversity in construction project teams, followed by a description of the relevant diversity dimensions. The focus will be on understanding the dimensions relevant to project teams, how they could affect the social structure within a project team, and this explains how it. The unique characteristics of the social structure that arise from diversity will be used to explain the effects of team diversity.

Sub-question 2: How are the diversity dimensions manifested within the project team?

The first part of the questionnaire for SNA, as described in Chapter 3, focuses on measuring the diversity characteristics of the project team that is chosen to be studied. The characteristics of the diversity dimensions within the teams are determined using a preliminary analysis of the survey data for each team. This forms the basis for identifying and studying the teams using quantitative measures such as centrality measures, density and cohesion within the team on the basis of relevant diversity dimensions.

Sub-question 3: How does diversity affect the distribution of power, influence, communication and clustering within the project team?

Analysing the informal organisational structure through SNA is the approach chosen to answer this sub-question in order to investigate the impact of diversity on the distribution of power, influence, and communication within the project team. A Social Network Analysis (SNA) survey will be conducted to assess this structure, focusing on four key relationship questions: frequency, responsiveness, effectiveness, and energy. By employing quantitative measures such as closeness centrality, betweenness centrality and PageRank centrality, clustering measures, and homophily, the effects of diversity on power dynamics, influence, communication and clustering patterns within the teams are revealed.

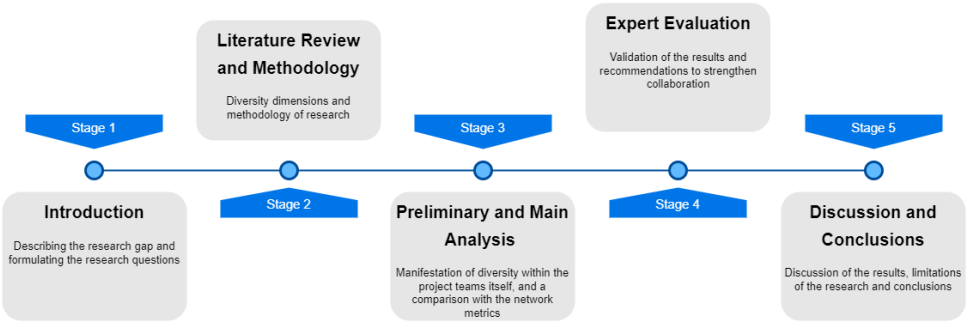
Sub-question 4: How can collaboration within the diverse project team be strengthened?

A few experts will be interviewed to uncover important explanations that may explain the disparities in sub-question 3. The interviewees will be project management experts. These interviews will be semi-structured, which means they will include more open-ended questions, allowing for a discussion between the interviewer and the interviewee rather than straight questions and answers. The aim of the interview is to get better insights into why the observed effects of diversity might be occurring, as well as ways in which the negative effects can be mitigated. Based on the expert interviews and the observations from this research, recommendations on how collaboration with a diverse project team can be strengthened are achieved.

1.4. THESIS STRUCTURE

- **Chapter 1 - Introduction: -** The difficulties and needs of diversity, as well as the need for network analysis, are outlined in this chapter. The corresponding lack of scientific research is described, and the research questions are formulated, followed by a brief description of the structure of the thesis itself.
- **Chapter 2 - Literature Review: -** This chapter aims to set the background with the concepts that will be used throughout this research, as well as to answer the first research sub-question. The chapter begins by setting the unique context of how project teams are conceived in the construction industry. The diversity in construction project teams and their dimensions are studied theoretically. The chapter will also develop a basic understanding of SNA and explore the formal organisational structure's effects on diversity and SNA within the project team.
- **Chapter 3 - Research Methodology: -** This chapter will introduce the various design choices of social network analysis and describes in detail how SNA will be used in this study. The survey setup and the techniques employed to clean the data and fill in missing values and the network analysis metrics are introduced. A detailed methodology will follow this.

- **Chapter 4 - Formal Organisational Structure and Diversity Dimensions in Practice:** - This chapter will be a precursor to the main analysis and will reflect on the preliminary data from the survey to show how diversity manifests within the project team, as well as plot the formal network of the team based on the organisational chart.
- **Chapter 5 - Project Teams' Network Characteristics:** - This chapter intends to study the key network attributes and a detailed network topology using network metrics from both project teams. The analysis includes an overview of fundamental network aspects and four major network metrics: closeness centrality, betweenness centrality, PageRank centrality, and average local clustering coefficient. An analysis of the significance of the results is done using the Kruskal Wallis-H Test to identify the significant diversity characteristics that can affect the network's power, influence and communication. The chapter also delves into the exploration of clustering and homophily within project teams and their potential susceptibility to being influenced by diversity characteristics. The chapter then summarises the findings to form the input for the expert interviews.
- **Chapter 6 - Expert Evaluation:** - This chapter presents the findings from the expert interviews. Building on the conclusions drawn in the previous chapter regarding the significance of diversity and its impact on collaboration, these interviews aim to understand the effects. The insights derived from these expert interviews will contribute to bridging the gap between theory and practice, offering valuable recommendations to strengthen collaboration within diverse project teams.
- **Chapter 7 - Discussion:** - This chapter discusses the research findings, their scientific contribution, and the study's limitations.
- **Chapter 8 - Conclusion and Recommendations:** - This last chapter gives a summary of the research's answers to the sub-questions, thus answering the main research question and making recommendations.



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LITERATURE REVIEW

This chapter focuses on describing the core ideas and concepts that will be employed in this report, as well as understanding the existing research on diversity and its implications on the social structure of a project team. This chapter will also help understand some of the fundamental concepts in formal organisational structure and its effects on diversity and social networks that will be relevant towards the end of this thesis.

The relevant literature for this chapter was found mainly based on online search, using keywords such as "diversity", "social network analysis", "network studies", "formal organisational network", "effects of formal organisational networks" and "homophily", primarily in Google Scholar, JSTOR, Sciencedirect, Emeraldinsights and Sagepub occasionally using regular Google search for web articles. The articles and papers were peer-reviewed and were as much as possible from reputed journals. The book, "The Hidden Power of Social Networks: Understanding How Work Really Gets Done in Organisations", by Rob Cross and Andrew Parker (2004) was paramount in understanding the network concepts and their usage to understand diversity quantitatively in this research.

This chapter aims to define the diversity dimensions in construction project teams from a literature standpoint. The distinctive elements that contribute to diversity in project teams are outlined, followed by a discussion of the diversity dimensions. The emphasis will be on understanding the dimensions that are significant to project teams, how they may impact the social structure of a project team, and also explain the potential effects that the formal organisational structure might have on the visibility of diversity in the project teams. This chapter also sheds light on social network analysis which will be the primary tool used in the quantitative part. The chapter answers the first sub-research question based on the literature study's theoretical findings.

2.1. CONSTRUCTION TEAMS AND THEIR UNIQUE CONTEXT

The notion of teams existed over a hundred thousand years ago, long before Hammurabi. However, teams formed during that period are on a modest scale (Robbins Harvey & Finley Michael, 2000). During the Industrial Revolution of the 1700s, organisational structures and business models changed, heralding the beginning of scientific management. People began to see the value of cooperating and working together since the results were far superior to working alone. Organisations formed functional teams in the 1960s but remained fragmented (Robbins et al., 2000). Construction teams are far more focused on being cohesive than in the past (Q. Zhang & Hao, 2022). When a team works together, they can share knowledge and resources, which helps to reduce the risk of human error, build better relationships, and improve the overall build on each job (Winstead, 2023).

The notion of a team with good collaboration is a significant concern for management in many sectors, including construction (Bureau of Engineering Research, 1992). The makeup of construction teams changes from stage to stage in a project's lifetime. This is true because the construction project team evolves collectively during the project, with new members coming in at various stages. Furthermore, the composition of the construction project team may vary depending on the size, kind, and complexity of the project (Uher & Loosemore, 2003). The construction team's distinctiveness may be noticed when it includes workers hired from different departments that have experienced different team cultures previously. The team is often constituted for a single project, with team members having never previously worked together and no assurance of ever doing so again. Construction projects are frequently coupled with schedule and cost restrictions. It is crucial for a team to completely comprehend the entire project setup and the importance of developing a successful team, as this can aid in developing more effective teams (Ogunlana et al., 1999).

2.2. DIVERSITY IN CONSTRUCTION PROJECT TEAMS

By a general definition, diversity is characterised as having people from various demographic backgrounds, such as gender, ethnicity, sexual orientation, age, religion, and country (Ely et al., 2016). Ely's (2016) definition of diversity covers functional and cultural diversity. Cognitive diversity is another type of diversity increasingly becoming relevant in diversity studies. Cognitive diversity is defined as including a variety of people with different thought patterns, ideas, problem-solving methods and mental perspectives within a project team or an organisation (Bender & Beller, 2016). Increased diversity (cultural, functional and cognitive) adds to the knowledge foundation a project team may rely on. Organisations are increasingly focusing on promoting diversity to incorporate new ideas and for ethical, legal, and public relations reasons; therefore, project teams are also becoming more diverse (Campbell et al., 2013; Østergaard et al., 2011). Thus, diversity management has taken on an important role in mitigating the issues of team diversity (Edewor & Aluko, 2007).

Earlier research on demographic diversity tended to take one of two approaches to understanding diversity: treating it as a wide mix, like heterogeneity, or concentrating on individual dimensions, because not all characteristics produce the same outcomes (Pelled, 1996). Team members in project teams have qualities such as cognitive capabilities or personality traits, as well as identifying attributes (age, race, gender, and so on) that distinguish them. These will be described as the diversity dimensions or diversity characteristics throughout this research. Workforce diversity is the manifestation of this notion in the workplace, and it refers to similarities and differences amongst employees in terms of age, cultural background, physical abilities and impairments, race, religion, gender, and sexual orientation (Saxena, 2014). Globally, there is a trend toward embracing heterogeneous project teams in numerous industries, because such teams are thought to be better at complicated problem-solving and designing new solutions, despite the problems that heterogeneity brings in the goal of forming an integrated team (Edwards & Edwards, 2002). Simultaneously, appropriate management of this diversity inside businesses and project teams is crucial (Watson et al., 2016).

The management of this diverse workforce is difficult because a new balance must be established that takes into account diversity and employee development while maintaining and achieving organisational goals (Saxena, 2014). Literature studies have also noticed that diversity has an impact on group interactions and results and have attempted to discover these linkages. Even though academics define team diversity in many ways, there is agreement that it is a multidimensional notion that encompasses a wide range of heterogeneities (Wu et al., 2019b).

2.3. DIVERSITY DIMENSIONS

This section aims to identify existing models that explain diversity in project teams and then summarise the models into a single set of diversity dimensions, that will be used throughout this study.

Powers-Twichell and Murphy (2011) backed up the idea that diversity is everywhere and in every team, because even in the most homogeneous groups, members have different ages, expertise, experience, and other characteristics that influence how they think and work. They understood diversity as more than just exposing one's team to diverse points of view; it is also a tried-and-true method for achieving more innovative and better results. Understanding the concept of diversity teaches that a paradigm shift, such as "seeing" things differently, will cause people to change their behaviours more naturally than if they were simply told to "do" something. By selecting project team members who see things differently because of their life experiences and encouraging them to respect and celebrate their diversity in background, opinion, and viewpoints, the team will be able to produce greater and more innovative solutions more rapidly.

According to Saxena (2014), workforce diversity refers to employee similarities and differences based on age, cultural background, physical abilities and impairments, ethnicity, religion, gender, and sexual orientation. No two people are alike. People differ not

just in terms of gender, culture, ethnicity, social and psychological traits, but also in their viewpoints and biases. For ages, society has discriminated on these grounds. The labour force is varied due to diversity. Employing a diverse staff is now a must for any firm, but managing such a diverse workforce is also a significant issue for management.

According to Pelled (1996), within a workgroup, diversity in terms of members' demographic origins can have a significant impact on both turnover and group performance in cognitive activities. While such diversity tends to boost turnover, its impacts on cognitive task performance are more varied, sometimes improving and sometimes hindering it. Understanding how diversity contributes to these outcomes can help managers improve work-team effectiveness. According to the suggested model, each demographic diversity variable may be categorised based on its visibility and job-relatedness. The degree to which the variable is easily noticed by group members is referred to as visibility, and the degree to which the variable directly moulds views and abilities relevant to cognitive activities is referred to as job-relatedness. The model then proposes that the visibility and job-relatedness of a diversity variable determine how much turnover and/or performance enhancement the variable potentially generates indirectly. More precisely, the visibility and job-relatedness of a diversity variable influence the degrees of effective (emotional) and substantive (task) conflict in the group, and the levels of effective and substantive conflict, in turn, influence group turnover and performance, respectively.

Wu et al. (2019b) took into account two broader dimensions: value diversity and knowledge diversity. Value diversity relates to the members' cultural values and tendencies, which might influence common goals, goal priority, and social integration. Knowledge diversity, which is comparable to functional diversity, refers to the essential knowledge traits, such as profession, expertise, and method of thinking.

From the different models described in this section, it is evident that there is little consensus on the diversity dimensions that are most relevant. Therefore, for this study we will be using the diversity dimensions that are described by Kyriakou (2022), in her thesis titled 'Exploring diversity in the project teams and how projects are affected', that summarises and validates the results of the models described above. In order to describe the diversity dimensions, she starts of with a diversity dimension matrix based on two axes, visibility and job-relatedness, based on Pelled, and aims to classify the various diversity dimensions identified above.

Based on the respondents in her study, the dimensions were classified into three categories: high, medium, and low value, as shown in Table 2.1. The goal was to have a better understanding of the outcomes and update the matrix accordingly. A questionnaire was built to assess the existing perception of diversity within the Netherlands. The assessment of the visibility and job-relatedness categories was used in the second phase, that focused on understanding projects and the project teams. In the third part of the questionnaire, where the diversity dimensions were investigated, respondents were asked to rate each dimension as high or low in terms of these two indices. The main conclusion was that the two indices were seen differently by the respondents.

Table 2.1: Categorisation of the presence of diversity dimensions in the team based on their assessment by the respondents (Kyriakou, 2022)

Low Value	**Medium Value**	**High Value**
Language (1.63)	Gender (2.28)	Functional Background (3.04)
Nationality/Origin (1.68)	Age (2.86)	Experience (3.14)
Race & Religion (1.14)	Education/Knowledge (2.64)	Organizational Tenure (2.91)
	Team Tenure (2.59)	

Based on the results above, the diversity dimensions were adjusted to match the real world. Figure 2.1 shows the changes that were observed in the relevance of the diversity dimensions. Finally, the diversity dimensions that are mainly visible are: Age, Gender, Language and Nationality/Origin. The dimensions that are mainly job-related are: Education/ Knowledge, Functional Background, Organisational Tenure, Team Tenure and Experience.

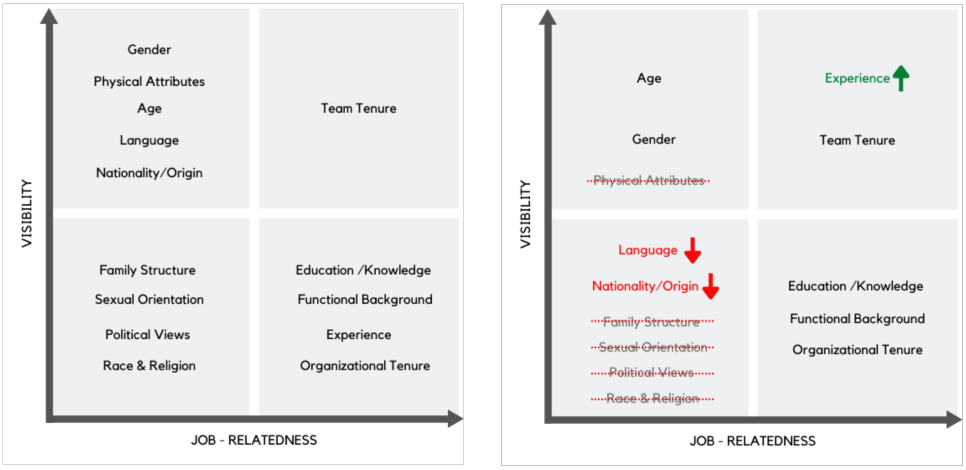


Figure 2.1: The initial form of the matrix and the adjusted form of the matrix respectively [Kyriakou, 2022]

2.4. SOCIAL NETWORK ANALYSIS AND ITS VIABILITY FOR DIVERSITY STUDIES

A social network is a collection of actors and the ties that connect them (some type of relationship, exchange, or interaction between actors that serves as a conduit through which resources such as information, trust, goodwill, advice, and support flow). Social network analysis (SNA) studies the social structure, connections, and strategic positioning of players in social networks using graph-theoretic and matrix algebraic approaches. SNA, as a methodological tool, enables academics to visualise and analyse webs of relationships to determine the composition, content, and structure of team networks, as well as their origins and dynamics, and then link these qualities to actors' attitudes and behaviours (Methot et al., 2022).

Most project teams have a formal structural diagram showing a designated chain of authority. This is usually based on a rational system that considers various factors such as experience in the company, qualifications, performance, and so on. However, an "informal network" is usually hidden behind the team's formal chart (Charles Kadushin, 2012). These informal networks are initially difficult to observe, but they are frequently responsible for how work is done in teams. According to research, it is nearly impossible to tell whether the relationships between people in a team are formal or informal. (Björkman & Kock, 1995). Informal relationships play an important role in ensuring that the team runs smoothly, and some authors even argue that informal relationships are critical to team effectiveness and market competitiveness (Arena, 2018; Abreu and Nunes, 2020).

Studies have also shown that an effective way to manage informal project team networks is to use graph-based social network analysis centrality metrics (Cross & Parker, 2004). Social network analysis is used to model pairwise relationships between members of a project team in order to help explain how social structures evolve over time and space and impact the environment in which they emerge and exist (Nunes & Abreu, 2020).

SNA can be used to explore how diversity (e.g., race/ethnicity and gender) is accommodated into the social structure when demographic factors are employed as actor attributes. The degree to which one actor is connected to the network is measured as a count of all links to other network participants. The degree of a tie can be deconstructed based on whether the actor initiated the connections (out-degree) or was the receiver of a connection (in-degree) (Pearson et al., 2018).

The transformative influence of data is one of the most significant potential benefits of SNA for diversity efforts. SNA might give people a new perspective on their communication and interpersonal behaviours. People are frequently motivated to improve their behaviour due to their discoveries. These new insights can be an excellent motivator for change.

2.4.1. COLLABORATION NETWORKS

A project can be used demonstrate how SNA may be used to explain the many features of a network. Most projects work with a well-defined team structure that enables employees to disseminate information to other project team members. Because collaboration is a dynamic activity, they frequently alter during the course of a project's life cycle. As the project progresses, team members join and depart the team, disagreements arise, and collaboration impediments emerge. Given the nature of the project team, new communication channels emerge while others vanish. As individuals acquire familiarity with one another, obstacles are frequently removed, and collaboration is improved (Guevara & Boyer, 1981).

2.5. FORMAL ORGANISATIONAL STRUCTURE AND ITS IMPACTS ON DIVERSITY AND SOCIAL NETWORKS

Formal organisational structure is a social structure that governs and constrains an organisation's members' communication patterns. It formalises the interaction between diverse business activities, processes, and people to achieve the firm's goals. Hierarchy, reporting lines, communication routes, and formalisation are all components of formal structure (Covin & Slevin, 1988). The levels of authority within an organisation are called hierarchies while reporting lines refer to the flow of information and decision-making within the organisation. Communication channels, such as email, phone, or in-person meetings, are the techniques used inside an organisation. Formalisation is the degree to which an organisation's policies, procedures, job descriptions, and norms are standardised and written down. Formalisation aids in reducing any deviations that could affect the firm. Because the role or position remains the same regardless of who holds it, the formal organisational structure strives to isolate the individual from it (University of Minnesota Library, 2015).

Formal organisational structures include multiple types of structure, including hierarchical, matrix, functional organisation and flat structures. The most prevalent type of organisational structure is a hierarchical structure, in which employees are grouped and assigned a supervisor depending on their role, function, geography, or the type of products or services they supply (Y. Li, 2019). A matrix structure is a type of organisational structure in which a person may report to more than one person and where cross-departmental duties and decision-making authority may exist. A functional organisational structure is similar to a hierarchical structure but is based on functions instead of positions. A functional organisation has the advantage of effectively utilising specialised resources and abilities. Grouping workers according to their areas of expertise can often boost productivity and performance (Awa, 2016). Employees are organised by their specific skills and expertise. A flat organisational structure has little to no tiers of administration between staff and executives. This structure is frequently described as horizontal, giving employees more autonomy and decision-making ability. It can, however, lead to communication breakdowns and a lack of clear direction (Y. Li, 2019).

Team dynamics, including decision-making, coordination, and communication processes, can be significantly influenced by formal structure. The degree of centralisation and formalisation in the structure of an organisation can influence how decisions are made, and information is shared within the team (Asana, 2021). A more centralised organisation may limit team members' decision-making capacity, whereas a more decentralised structure may allow for greater autonomy and collaboration. Formalisation can also impact team dynamics by specifying roles, responsibilities, and procedures, which can reduce confusion and enhance coordination (Asana, 2021). Too much formalisation, however, can lead to rigidity and inflexibility, which can stifle innovation and creativity. The sort of team structure can also affect team dynamics (University of Minnesota Library, 2015). A hierarchical organisation, for example, may offer a clear chain of command but may impede communication and collaboration among team members. A flat structure, on the other hand, may enhance communication and collaboration but may result in a lack of clear direction and accountability (University of Minnesota Library, 2015). Overall, an organisation's formal structure can considerably impact team dynamics, and it is critical to evaluate the benefits and drawbacks of various structures when establishing teams and making decisions (University of Minnesota Library, 2015).

Several studies have been conducted to study how formal organisational structure affects the establishment and configuration of social networks inside the project teams/ departments (Michalski & Kazienko, 2018; Rank, 2008). According to one study, while formal structures are designed to maximise effectiveness, informal cooperative networks that emerge from structured interactions between organisational players, often play a more significant role in determining the level of collaboration within the teams (Rank, 2008). Another study proposes that aligning organisational structure and social networks may improve overall firm management by comparing estimated node position ranks inside the organisational structure (Michalski & Kazienko, 2018). A third study examines the importance of formal rank, authorisation procedures, and departmental affiliation in explaining informal information seeking among government employees, emphasising the link between official organisation and informal social structure (Whetsell et al., 2021). Overall, the findings indicate that formal organisational structure can influence the formation and configuration of social networks inside teams, and that understanding the link between formal and informal structures is critical for effective team management.

Studies have examined the combined effects of diversity and formal structure on team social networks (Mayo & Pastor, 2011; Tröster et al., 2014). One study found that the degree of diversity in a team influences the density and centralisation of communication within the team (Mayo & Pastor, 2011). Another study found that the positive effects of network density on team potency and the level of network centralisation required for optimal team performance were contingent on team composition, with more culturally diverse teams requiring a more pronounced degree of centralisation (Tröster et al., 2014). A team formation algorithm was proposed in another study that suggests diverse teams based on individuals' social networks, allowing them to keep high familiarity levels within an organisational network (Das et al., 2021). Overall, these studies suggest

that the interaction effects of diversity and formal structure on team social networks are complex and contingent on team composition.

2.6. CONCLUSION LITERATURE REVIEW

This chapter on literature review aims to set the foundation of the basic concepts used throughout this thesis. The chapter started by describing the context of how construction teams are formed and their unique attributes and constraints. The importance of incorporating diversity in the construction industry follows, which concluded that diversity in the workforce improves the creativity and productivity of project teams while also helping team members feel welcomed into the project teams that they work with (Paulus et al., 2016). But, they also suffer from weaker group dynamics and more disagreements (Tröster et al., 2014). In this thesis, SNA is used to study the social structure, connections and strategic positioning of actors in the project team, thus visualising how diversity may change the factors mentioned above. This literature review also aims to answer the first sub-research question of this thesis, '**What is diversity in project teams from a theoretical perspective?**'.

Diversity in project teams refers to all of the features that team members possess that set them apart. Personal attributes and job-related characteristics are the two main types. Personal traits are characteristics such as age, gender, physical characteristics, language, nationality & origin, race & religion, family structure, sexual orientation, or political views that are associated with an individual's personality, determine how they perceive issues and conditions, and affect their interpersonal relationships. Education and expertise, functional background, experience, and organisational and team tenure are all job-related traits. Based on the study by Kyriakou (2022), this list can be further reduced to include only the most relevant dimensions. Age, gender, language and nationality were the pertinent attributes identified in personal traits. Knowledge, functional background, organisational tenure and team tenure were identified as critical job-related traits. The survey developed in Chapter 3 will be based on the reduced list of diversity dimensions identified from the literature.

3

RESEARCH METHODOLOGY

This chapter focuses on laying out the research methodology followed throughout this research. The chapter begins with a summarised research approach. It then goes into detail about this approach with the design choices concerning social network analysis mentioned in the research approach.

3.1. RESEARCH APPROACH

This thesis will employ an explanatory approach in its research to understand the various effects of diversity on the network structure of a project team. Explanatory research is a research method that explores why something occurs when limited information is available. In this situation, a quantitative tool called social network analysis will be used to interpret the data to help answer the main research question. Figure 3.1 gives a brief overview of the various phases this thesis will be divided into, indicating the sub-questions that will be answered in the relevant phases. The first part focuses on building an extensive team profile that charts the formal network structure of the team that will be studied. Two teams are chosen to be studied. The teams that will be studied are chosen based on their cultural, functional and cognitive diversity. The teams will be between 20-80 people in size. A detailed organisation profile is built to understand the formal structure of the teams within the organisation.

The informal network of the organisation is determined through surveys that reveal relationships between actors on four characteristics, namely frequency, responsiveness, effectiveness and energy (Cross & Parker, 2004). Two surveys will be conducted to obtain relational data. The first survey, or the preliminary survey, aims to define the boundaries of the team and will focus on collecting data on the diversity characteristics within the team and allow the respondents to identify people that may have been missed. This will be followed by a second survey, or the main SNA survey, sent out once the preliminary survey is closed with questions to collect data to map the actual relationships. Every other survey taker of that team will be scored on a 0-5 linear scale. Once the surveys are

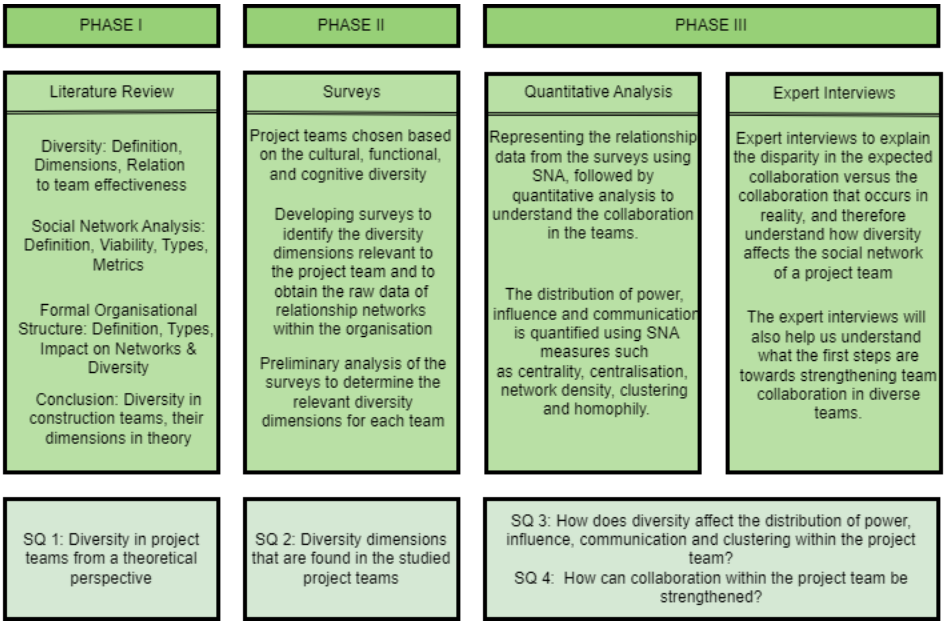


Figure 3.1: Research Approach Overview

closed out, the data is cleaned by removing incomplete responses, and the response rate is measured. To understand the relationships within the teams, it is important to have at least a response rate of 85% on the main survey, as anything lower than that would miss out on important relationships that may exist. Imputation techniques are applied as required to complete the missing data.

The relationship data from surveys is visualised using Gephi and NetworkX in Python. Various quantitative measures are calculated, including network centrality (such as closeness, PageRank, and betweenness centrality), network clustering, and network density. These measures help identify highly connected individuals, popular individuals, knowledge holders, and facilitators of network connections. The results are verified for accuracy through informal discussions with the team leads to ensure that, at a fundamental level, the visualisation of the network is accurate and to develop an understanding of the clusters that form within the team organically. This qualitative study will focus on understanding why certain individuals hold specific positions in the network and how it might be a product of the group's diversity or the lack thereof.

Expert interviews are then conducted to validate the results of the quantitative study and get a practical perspective into why the observed phenomena occur. The final part of this research focuses on compiling the results from the quantitative analysis, as well as the interviews to provide results on how diversity affects social network structures in the construction industry and also provide recommendations to reduce the adverse effects

of diversity in future projects while reaping its benefits.

3.2. EGO-CENTRIC VS GROUP-BOUNDED APPROACH

There are two ways to perform a Social Network Analysis (SNA): personal (egocentric) and group (bounded) network assessments (Wasserman & Faust, 1994). The personal network technique asks a person to identify other people significant for a specific function or task (such as learning or information) and then respond to a series of questions about each person. The group (or bounded) network method begins with defining a network of interest, such as a crucial team in an organisation or a group of individuals essential to a core activity. Everyone in the group is surveyed on their relationships with everyone else. Unlike the personal network method, a list of names from the group to survey is known. This thesis will use a hybrid approach that combines the best features of personal and group approaches. In this hybrid approach, the members of the project team are known. Still, the survey also allows identifying members that may have been missed out, therefore giving us the option to survey the newly identified members.

3.3. CHARACTERISTICS AND SIZE OF THE TARGET TEAM

Identifying a project team in which effective collaboration is vital for an organisation is crucial in this study. This thesis will look at teams where good collaboration results in strategic and operational benefits for an organisation. We also seek teams that span functional, organisational, and physical barriers, as these are significant areas of network fragmentation. Another essential factor to consider is the team size that will be researched. Social network analysis can be conducted on entire organisations. In reality, we are constrained by people's willingness to complete lengthy surveys.

For this research, the study will be performed on teams from a major engineering and consultancy firm within the Netherlands, which specialises in infrastructure development worldwide. Two teams are chosen to be studied. The teams that will be examined are selected based on their cultural, functional and cognitive diversity. The teams will be between 20-80 people in size, and teams where good collaboration results in strategic and operational benefits for an organisation are chosen for this study. From the organisation's perspective, this would imply that the teams will ideally have members from different backgrounds, such as engineering, architecture, planning, logistics, etc. The team will be relatively well established (past the forming stage in Tuckman's model) to avoid inconsistencies in the data due to teething problems (Tuckman, 1965).

3.4. DATA COLLECTION METHODS

SNA may use primary and secondary data sources. Interviews, surveys, and observation, or any mix of these, are the most popular primary data sources (Williams & Shepherd, 2017). Tracking email chains, existing databases, firm social networking platforms, and observable data, like attendance at public events, may be used as secondary sources

for SNA studies. Data collecting techniques must be consistent with the level of analysis required by the research, which is based on the requirements of the main research question. Because of the significant burden of collecting sensitive and extensive relational data from participants, using secondary data, when accessible, is far more time-efficient. Primary data sources will be employed to acquire information on the social network of the project teams for this thesis. There are no secondary data sources with the information required for this study, as the study focuses on two construction project teams in the Netherlands. The information collected will be utilised to study the team's network structure. Surveys and interviews are used to gather information on the team members, their roles, and their interactions. Network metrics will be utilised to study team members' behaviour and uncover interaction patterns.

3.5. SETUP OF THE SURVEY

Following identifying a strategically significant group, the next phase in a social network analysis is to collect the information required to map the relationships. Relationships must genuinely expose the inner workings of a group. In this scenario, surveys will be utilised to obtain data for mapping the network. Appendix B presents various relationship questions useful in uncovering crucial network links. While the survey data only needs to collect responses from one person in a two-person relationship pair, our survey gauges both sides' opinions to create a more realistic and unbiased picture of the team. It can also assist in determining when someone tries to exaggerate their importance in a network by claiming to collaborate with everyone (but others do not recognise this).

The survey has been split into two parts to make the hybrid approach of SNA work. The first survey called the preliminary survey, determines the diversity characteristics the participants fall into based on the diversity dimensions identified in the literature study above. Individual diversity dimensions are separated into several "sub-groups" to classify individuals into numerous subgroups based on their diversity features. Thus the preliminary survey is critical for the research, as it helps to generate the required information to form the various sub-groups based on diversity characteristics. The preliminary survey also helps to identify members that may have been missed by giving the survey takers the option to add names of team members they feel are relevant to the study, thus aiding the hybrid approach. A sample of the preliminary survey is presented in Appendix A.

Relationship questions form the basis of the second survey, hereby called the main survey/ SNA survey. Relationship questions help identify network rigidities. Mapping decision-making and workflow helps to understand how a team's network structure or task design may be overburdening it. And such representations may be significant predictors of an organisation's climate. Cross et al. (2004) developed four distinct characteristics (frequency, responsiveness, effectiveness, and energy) to reflect the nature of an organisational relationship. These will be the four relationship characteristics that will be used to map the relationships in the network. The set of questions shown in Appendix

B acts as a guideline for the questions in the final survey, and the questions will be chosen based on discussions with the project leaders. A sample of the main survey that will be sent out is presented in Appendix C.

To assess the quality of relationships, it is critical to understand the interaction type rather than just whether contact occurs. When adopting a valued method, a score of 0 to 5 can offer insight into the quality of the connection. This approach, therefore, gives information into whether or not an interaction between specific individuals is occurring and the nature of the relationship.

3.6. DATA PREPARATION

For the analysis done in SNA to be accurate, a high response rate (>85%) is required for the main survey (De Brún & McAuliffe, 2018). This is because social network analysis heavily relies on data collected from the surveys. If some team members do not respond, the resulting network may not represent genuine relationships and interactions.

Missing data is a common issue in social network analysis surveys, and imputation is an excellent method to fill the gaps. Imputation techniques fill in missing values to maintain the full sample so that standard SNA software can easily analyse completed data. Mean imputation and multiple imputation is a general approach to the problem of missing data that is available in several commonly used statistical packages (Sterne et al., 2009).

Mean imputation is a simple imputation method that involves substituting missing values with the mean or median of the relationship variable. Mean imputation is a quick and easy way to handle missing data. It is often used when the amount of missing data is small or, for this research, if the majority (> 90%) of the relationships are reciprocal (Salgado et al., 2016). One of the benefits of mean imputation is that it is easy to implement and can be done quickly. However, mean imputation can lead to biased estimates of the actual values, especially if the missing data is significant. Therefore, researchers are more cautious when using mean imputation and often consider other imputation methods, such as multiple imputation, which can provide more accurate estimates of the missing values (He, 2010).

Multiple imputation is a more advanced imputation technique that generates several plausible imputed data sets by filling in missing values with estimated values based on the observed data (P. Li et al., 2015). By creating several different plausible imputed data sets and appropriately combining results obtained from each data set, multiple imputation allow for the uncertainty about the missing data to be considered. Multiple imputation is particularly useful in network analysis when the data is not reciprocal, as it allows for estimating missing values based on the observed data (Salgado et al., 2016). This technique can therefore improve the validity of network analysis results by providing more accurate estimates of the missing values. In this thesis, all the imputation required

will be performed by IBM SPSS, and the validity of the data will be checked by measuring the variations in network metrics, if any, using Gephi.

3.7. NETWORK ANALYSIS TOOLS

Gephi and NetworkX, a package in Python, will be used to visualise the relationship data obtained from the surveys. This will help to learn the effects of the various perspectives on the dynamics of a team from both sides and also understand the gap within the relations using a few quantitative measures such as network centrality, density, network centralisation, clustering and homophily. Network centrality is a set of SNA measures that measures how important a person is to a team and consists of a wide range of measures. It is critical for locating highly connected individuals (closeness centrality), popular persons (PageRank centrality), individuals likely to own the most significant knowledge, or those who can swiftly link with the larger network (betweenness centrality). Centrality measures are also used to identify the relationship gaps in the network. In social network analysis, network clustering can show the connectedness and togetherness among actors within a network. This measure can be used to identify the ease with which collaboration can occur in the network. Network density measures the proportion of dyadic connections or direct ties inside a social network. Network density provides insight into all the possible connections and demonstrates the potential to which the current network can expand.

3.7.1. DESCRIPTION OF THE METRICS

The main network metrics used in this research are described briefly below. Figure 3.2 shows a dummy network to understand the network metrics better.

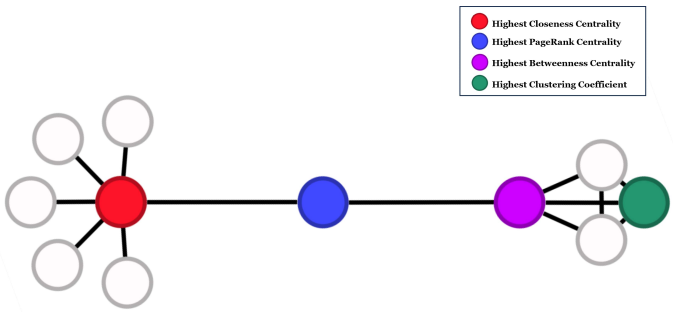


Figure 3.2: Example Network

Closeness Centrality: - The average length of the shortest path between a node and every other node in the network is known as closeness centrality (Borgatti & Everett, 2006). It aims to identify nodes that can quickly access and spread information throughout the network. Nodes with high closeness centrality are considered more central in the network because they can efficiently communicate and disseminate information to other

nodes. Closeness centrality is particularly useful in identifying influential nodes or individuals who can efficiently spread information, control the flow of communication, or facilitate collaboration in a network.

Betweenness Centrality: - The relevance of a node in tying together various members of a network is gauged by betweenness centrality. According to Freeman (1977), it detects nodes that act as gatekeepers or bridges, tying together areas that would otherwise be separated and preventing the network from disintegrating. Betweenness centrality focuses on nodes that have a high potential to control the flow of information or communication between other nodes. They often lie on paths that link disparate parts of the network or connect nodes that are not directly connected. They serve as vital conduits for communication, collaboration, and coordination, and their removal or disruption can significantly impact the network's functioning and efficiency (Borgatti & Cross, 2003).

PageRank Centrality: - PageRank centrality is a widely used metric in social network analysis that measures the importance of nodes or the power of the nodes in a network. This is done based on connectedness and the significance of nearby nodes. The measure, which was initially created to evaluate web pages, can also be used to rank social networks (Page & Brin, 1998). Nodes in social groups with strong connections to other significant nodes are likely to be more powerful. As a result, PageRank Centrality can pinpoint powerful people or groups inside a social network.

Average Clustering Coefficient: - The average clustering coefficient gauges how much a network's nodes tend to group together, or form closely knit groupings. It is an indication of the network's degree of cohesion and is influenced by the diversity of nodes and connections, according to a study by Watts and Strogatz (1998). It quantifies the extent to which a node's neighbors are interconnected. Nodes with high local average clustering coefficients indicate the presence of cohesive clusters or tightly connected groups of nodes around the focal node. This metric is valuable because it provides insights into the level of local cohesion or clustering within a network. Nodes with high local average clustering coefficients tend to be part of closely knit communities or groups, where information, interactions, or resources flow within the cluster.

Clustering: - Clustering in a social network refers to the formation of cohesive groups or communities within the network based on patterns of social interactions or relationships. It involves identifying clusters of individuals or nodes more densely connected within the network than nodes outside their cluster (Newman & Girvan, 2004). The subgroups formed within project teams can then be determined using community detection algorithms to find cohesive clusters. The Louvain algorithm is a popular community detection method frequently used in social network analysis. The iterative approach seeks to maximise the network's modularity score, gauging how well the network is divided into communities. The Louvain algorithm is successful and efficient at locating communities and, therefore, will be used to detect cohesive clusters in the project teams (Nguyen et al., 2008).

Homophily/ Assortativity: - Homophily or selective interaction refers to the tendency of individuals or nodes in a network to form connections or relationships with others similar to themselves in some way (McPherson et al., 2003a). Individuals with similar traits or preferences are more likely to interact and form connections with each other, leading to the formation of homophilic clusters within the network (McPherson et al., 2003b). Homophily plays a significant role in shaping the structure and dynamics of social networks. In the context of project teams, homophily can manifest in new members gravitating towards team members who share similar characteristics, thereby creating a sense of comfort and familiarity.

The assortativity coefficient is a measure of homophily. In the context of project teams, the assortativity coefficient can be used to determine the degree to which team members are similar to one another interact. The values of the assortativity coefficient vary from -1 to 1. While a coefficient of 1 shows that team members are solely connected to other team members who share the same diversity characteristics, a value of -1 indicates that nodes in the network are only connected to others who are dissimilar to themselves. Project teams or real social networks typically display assortativity coefficients closer to 0 than -1 or 1. This is because individuals in social networks often have multiple diversity characteristics, leading to a mixing of connections that one characteristic does not completely determine.

3.7.2. STATISTICAL SIGNIFICANCE OF THE RESULTS

The Kruskal-Wallis H test can be used to determine if there are significant variations in SNA measurements, between various groups based on the diversity dimensions. According to the diversity dimension being studied, the test would specifically assess whether there are significant differences in the medians of the SNA measures between the various groups (M. Ross, 2014). The null hypothesis used throughout this study is that there is no significant correlation between a diversity characteristic and the network metric it is compared against. A significant difference ($p<0.05$) would indicate a strong correlation between the diversity characteristic under analysis and the SNA metric, and a significant difference ($p<0.1$) is used cautiously in the study to show marginal significance (Wasserstein & Lazar, 2016). The four network metrics and their centrality scores for each member of the team were chosen as the dependent variable in this analysis. The independent variables are the diversity characteristics that are measured for each member of both teams.

Furthermore, it is important to ensure that the assumptions of the Kruskal-Wallis H test are met, such as the independence of the observations, the random sampling of observations, and the homogeneity of variances. Failure to meet these assumptions can lead to inaccurate results and conclusions. Therefore, these assumptions are checked with the data for both the teams in IBM SPSS manually and automatically depending on the assumption.

4

Formal Organisational Structure and Diversity Dimensions in Practice

In this chapter, a description of the two teams chosen for the study is provided, along with a detailed description of the formal organisational structure of the teams. A preliminary survey was undertaken to collect diversity data from individuals working in the two teams. Participants' names, ages, genders, educational qualifications, job experience, nationality, office location, work packet/department and team tenure were all captured in the survey. This survey aimed to collect data for a subsequent main survey (SNA Survey).

4.1. Method and Responses

The survey was distributed to members of Team 1 and Team 2. Team 2 comprises members from two organisations: the client and the contractor. The survey was sent to 59 members in Team 1 and 37 in Team 2. The survey consisted of open-ended questions and took approximately 5 minutes to complete. The survey was distributed online and was made available in English. The initial survey response rate was rather poor, with 33% (20 out of 59) at Team 1 and 27% (10 out of 37) at Team 2.

Response rates for diversity surveys can vary greatly, according to research, with some studies claiming response rates as low as 10% and others reporting rates as high as 90% (Sykes et al., 2010). The amount of anonymity granted, the length and complexity of the survey, and the level of trust and involvement team members have with the organisation are all factors that may impact response rates. An interactive session emphasising the thesis's importance to the organisation's diversity and inclusion efforts and general research was conducted to increase response rates. This drastically increased the re-

sponse rate to 90% within Team 1 and 68% within Team 2. Team 1 survey responses showed some inclusion of temporary members, as the survey was sent out in their combined team meetings. These members were later removed as they could not participate in the main survey. Finally, Team 1 comprises 46 members, and Team 2 consists of 25 members. The preliminary surveying process was done in 8 weeks, starting from December 2022. Having established the survey methods and the response rates, we now turn to the analysis of the survey data to gain a deeper understanding of the diversity characteristics within the two project teams.

4.2. THE TEAMS' FORMAL ORGANISATIONAL STRUCTURES

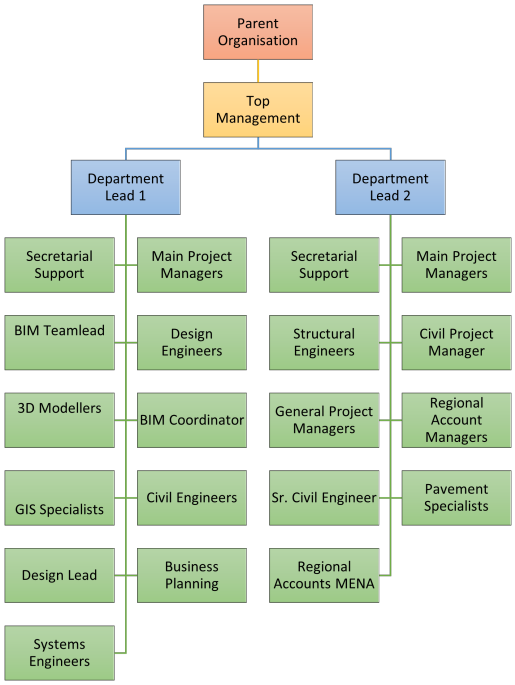


Figure 4.1: Formal Organisational Structure of Team 1

Two teams were chosen from a leading engineering and consultancy firm in the Netherlands based on the best fit for the criteria mentioned in Section 3.3. Team 1 consists of two departments in a subsidiary organisation of the parent organisation, with its independent top management to the parent organisation. Team 1 works with clients from different countries, and hence the team consists of members from over 10 different countries, along with a team working full-time in South Africa. Team 1 comprises 46 members, with around 12 working in South Africa. Team 1 shows a matrix organisational structure where the reporting structure forms a grid-like structure, as shown in Figure

4.1. Team members with the same job titles have been grouped in Figure 4.1. The team members in this structure report to the main project managers and the department leads. This works by grouping the team members and resources by function and project. Team 1's organisational structure advantages are flexibility and adaptability, a focus on project goals, and harmony between functional and project-based work (Project Management for Development Organization, 2011).

Team 2 is a project team made of clients and consultants. They are responsible for the design process in reinforcing critical dyke sections in various Municipalities within the Netherlands. The team consists of 37 members. Team 2 has a functional organisational structure, with the main project manager of the client side having a full line of authority over the project. Figure 4.2 shows the formal organisational chart that defines each team member's function and reporting lines. Such an organisational structure focused on a project can leverage specialised expertise and optimise resource allocation. However, it requires careful attention to communication, coordination, and balancing priorities to overcome potential limitations and ensure successful project outcomes (Awa, 2016).

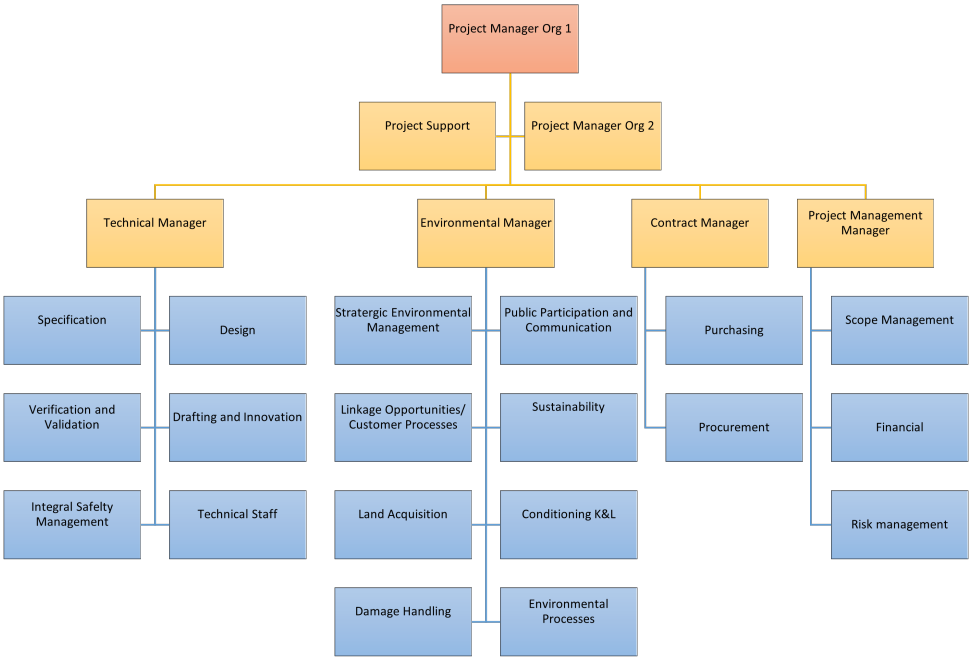


Figure 4.2: Formal Organisational Structure of Team 2

4.3. DIVERSITY CHARACTERISTICS OF THE TEAMS

The largest group of participants at Team 1 were between the ages of 30 and 40 (39.6%), followed by those between the ages of 40 and 50 (26.4%), as shown in Figure 4.3. In Team 2, the largest group of participants were between 40 and 50 (41.6%), followed by those between 50 and 60 (25%). 74.1% of the respondents at Team 1 identified as male, while 24.9% were female. On Team 2's side, 76% of the respondents were male, and 24% identified as female.

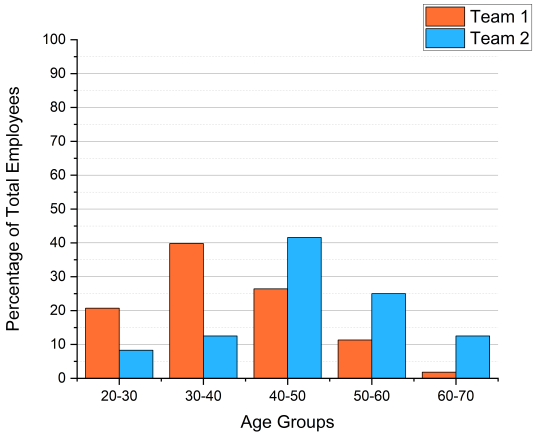


Figure 4.3: Age Distribution Graph

Regarding educational qualification, in Team 1, most participants held a bachelor's degree (53.7%). In comparison, 33.3% held a master's degree, followed by 11.1% who had a secondary school degree, and 1.9% held a doctoral degree, as shown in Figure 4.4. Team 2 showed a shift in educational qualifications, with a majority of team members having a master's degree at 52%, followed by a bachelor's degree at 40%. 8% of the respondents at Team 2 had a secondary school degree, and no one had a doctorate.

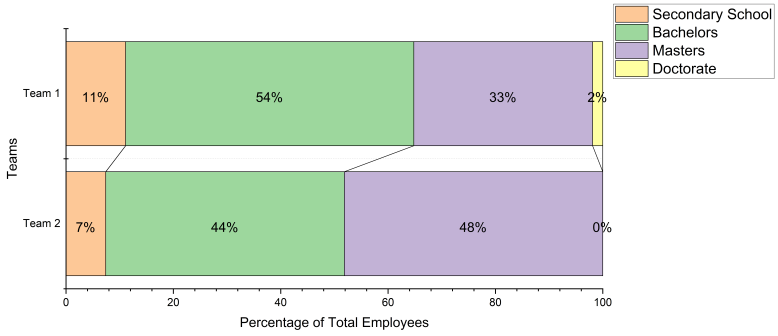


Figure 4.4: Distribution of Educational Background at Team 1 and Team 2

Team 2 respondents appear to have significant work experience. 8% of the team members have 0-10 years of work experience, 46% have 10-20 years of work experience, 32% have 20-30 years of work experience, and 12% have 30+ years of work experience. There is a skew in work experience in Team 2, with most respondents having more than 10 years of experience, leaving a relatively small percentage of members with shorter careers.

The largest group of respondents at Team 1 have 10-20 years of work experience, with 32.6% of members having 0-10 years, 41.3% having 10-20 years, and 17.4% having 20-30 years of work experience. Only 8.6% of persons in the category have 30+ years of work experience. According to the statistics, most team members have some experience but are not yet past the peak of their careers. There is also a dearth of diversity in terms of highly experienced workers, with only a few having more than 30 years of expertise. The work experience of Team 1 and Team 2 respondents have been summarised in Figure 4.5.

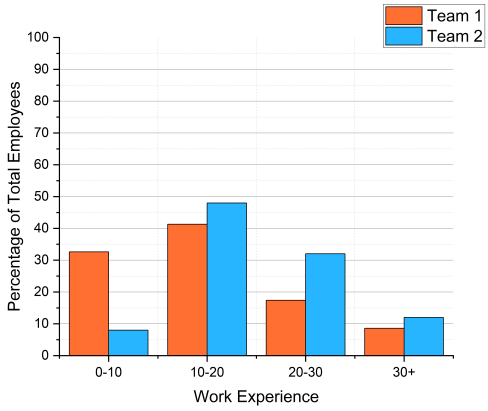


Figure 4.5: Work Experience Distribution at Team 1 and Team 2

Most Team 1 respondents have worked in their teams for over six years, with 58% of the team members falling into this group. Furthermore, 41% of members have 0-5 years of team tenure. 15.2% of the team members have been with their teams for over 15 years.

The majority of Team 2 respondents have relatively limited experience working together (i.e. team tenure), with 24% of the members having one year of team tenure, 12% having two years, 16% having three years, 26% having four years, and only 4% having five years of team tenure. Only 12% of team members have six or more years of experience. It's worth noting that the project team was formally constituted in 2018, and several shuffling and changes have been made since then. The team has some diversity in terms of years of team tenure, with a good mix of members who have been working together for one year to five years.

Team 1 is a diverse firm under the main organisation, with 52% Dutch members, 28% South Africans, and 32% members from other countries. This diversity stems from the fact that Team 1 is a global organisation that specialises in projects worldwide and hence hires professionals worldwide to work on projects in various nations. Team 2, on the other hand, is entirely made up of Dutch members. This is because the project has a municipality as the client; hence, all communications happen in Dutch. Figure 4.6 shows a pie graph with the percentage share of each of the countries within the survey takers in Team 1.

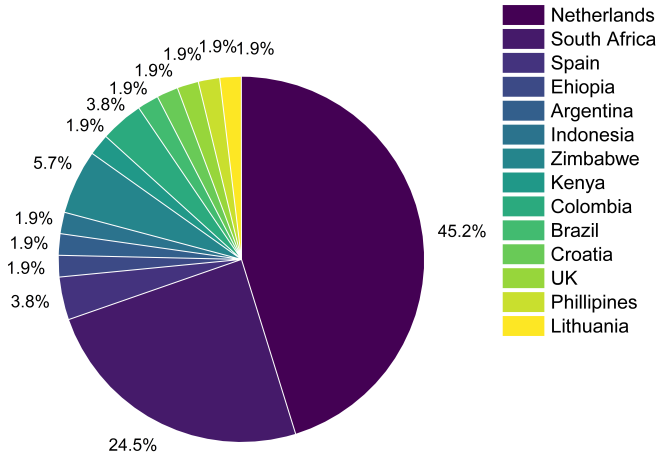
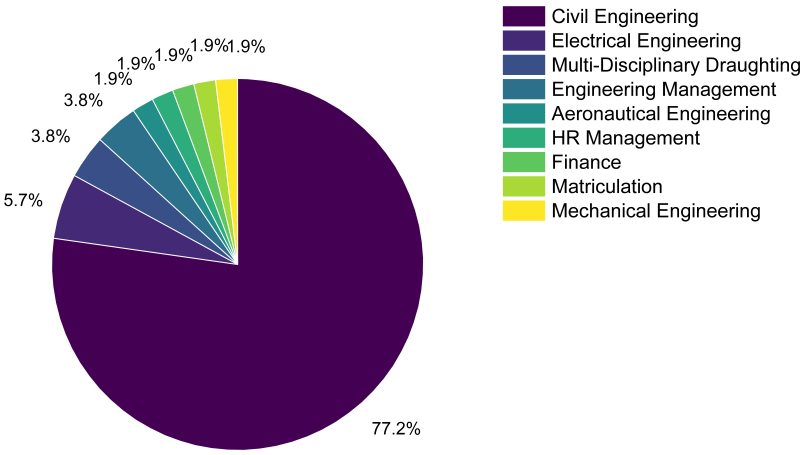
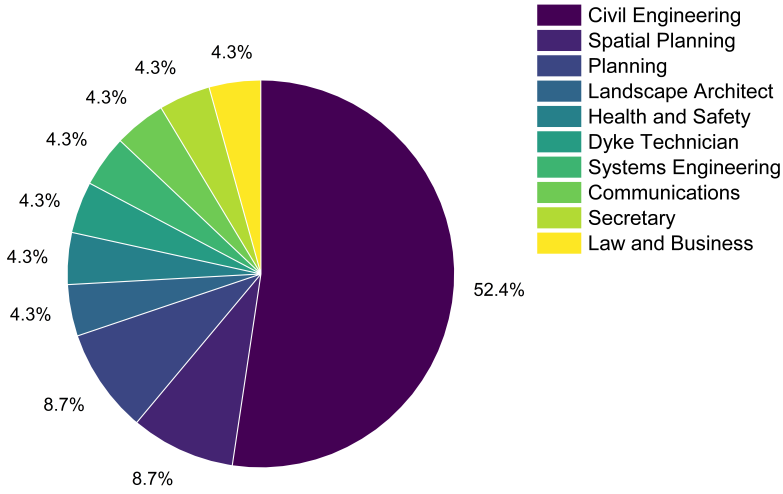


Figure 4.6: Nationalities Distributions at Team 1

The functional background of the 46 respondents from Team 1 is dominated by Civil Engineers (77.2%). The rest of the team comprises members from other functional backgrounds, such as Aeronautics, Electrical, Multi-Disciplinary Draughting, Human Resources, Engineering Managers, Finance, and Mechanical Engineering, making up the other 22.8% of the team. This shows that most respondents had an engineering background. The dearth of representation from areas other than engineering is likely due to the organisation's focus on engineering products. Figure 4.7a shows the percentage division of each one of the functional backgrounds in Team 1.



(a) Functional Backgrounds Team 1



(b) Functional Backgrounds Team 2

Figure 4.7: Functional Backgrounds of the Two Teams

The functional background of the 25 respondents from Team 2 is relatively more diverse, with representation from various fields, including engineering, safety and health, architecture, planning, communications, and administration. Specifically, there are 48% Civil Engineers, and the rest of the team consists of 1 Systems engineer (4.3%), 1 Dyke Technician (4.3%), 1 Health and Safety (4.3%), 1 Landscape Architect (4.3%), 2 people in Spatial Planning (8.7%), 2 people in Planning (8.7%), 1 person in Communications (4.3%), 1 Secretary (4.3%) and 1 person in Law and Business (4.3%). This diversity likely reflects the multi-disciplinary nature of the team's work, which likely involves collaboration with clients and contractors from a variety of fields. The presence of professionals

from different backgrounds, such as Law and Business and communications, suggests that the team is well-equipped to work with different stakeholders. Figure 4.7b shows the percentage division of each one of the functional backgrounds at Team 2.

4.4. ADDITIONAL PARAMETERS IDENTIFIED

In addition to the diversity dimensions discussed in the literature, this chapter identifies aim to define three additional parameters that are essential to capture the unique characteristics and setup of the teams under investigation. These parameters include the Organisation (Team 2), Location (Team 1 & 2), and Department (Team 1). While these parameters are not diversity dimensions, they can affect the social structure of the team and are therefore studied to account for some of its effect on the project teams' social structure.

In Team 1, the team operated from two primary locations: the Netherlands (NL) and South Africa (SA). The majority of the team, 69.5%, was based in the Netherlands, while the remaining 30.5% worked in South Africa. The team could be divided into two departments, with members in the departments being present in both NL and SA offices. Department 1 (Dep 1) constituted the main team under study, accounting for 76.1% of the total team members, while Department 2 (Dep 2) included 23.9% of the members. Notably, all members of Team 1 belonged to the same organisation.

In Team 2, the composition consisted of members from two different organisations, with a nearly equal distribution between the two. Organisation 1 (Org 1) comprised 40% of the team, while Organization 2 (Org 2) made up 60% of the team members. Team 2 operated from five distinct locations within the Netherlands. The majority of the team members (36%) worked from Ijzendoorn (NL), while the remaining team members were distributed across Eindhoven (NL) (4%), Amersfoort (NL) (24%), Tiel (NL) (20%), Rotterdam (NL) (4%), and Nijmegen (NL) (12%).

Including these parameters in the study design will enhance our understanding of the specific context and unique characteristics of the teams, especially when considering the social structure of the project team.

4.5. DIVERSITY SUB-GROUPS

The finalised list of the diversity dimensions, their sub-groups and the additional parameters are described below to form the input for the diversity dimensions, additional parameters and their subgroups used in the next chapter. The diversity dimensions and the other characteristics were divided into multiple categories, and the categories are shown in Table 4.1

Table 4.1: Diversity Dimensions, Additional Parameters and their Corresponding Sub-groups

Diversity Dimension & Parameters	Sub-Groups
Age Group	20_30, 30_40, 40_50, 50_60, 60_70
Location	SA, NL (Team 1) / Amersfoort, Tiel, Eindhoven, Nijmegen, Ijzendoorn
Department	Department 1, 2 (Team 1)
Organisation	Organisation 1, 2 (Team 2)
Nationality	Dutch, SA, Misc (Team 1) / Dutch (Team 2)
Gender	Male, Female
Experience	0_10, 10_20, 20_30, 30+
Team Tenure	0_5, 5_10, 10+ (Team 1) / 1, 2, 3, 4, 5, 5+ (Team 2)
Education	Secondary School, Bachelor, Master, Doctorate

4.6. CONCLUSION

The data provided above describes the demographic characteristics of the respondents from two different teams, 1 and 2, within the same parent organisation. It offers demographic details of their age, gender, educational qualifications, work experience, team experience and nationalities. We can, thus, answer the second sub-question, **'How are the diversity dimensions manifested within the project team?'**.

The largest group of participants in Team 1 were between the ages of 30 and 40, while in Team 2, the largest group were between 40 and 50. The majority of respondents at both Team 1 and Team 2 were men. Regarding educational qualifications, Team 1 had most participants with bachelor's degrees, while Team 2 had most team members with master's degrees. Team 1 is a diverse firm with a mix of different nationalities, while Team 2 comprises completely Dutch members. The data also shows that the majority of Team 1 respondents have worked within their team for more than six years, while Team 2 is still in its development stage with a good mix of members who have been working within their team for one year to five years. In terms of the functional background, Team 1 is not as diverse as Team 2, though culturally, Team 1 is more diverse than Team 2. This is mainly due to client involvement in Team 2, which brings in more functional backgrounds other than engineering, which is the primary focus of all the respondents of Team 1.

These findings will be used in further analysis to examine the relationship between diversity and the social structure of a project team using social network analysis. It's important to note that the data presented here are preliminary, and further analysis is needed to draw more meaningful conclusions. Additionally, the survey only captures a snapshot of the diversity within the organisation and more research is needed to understand the dynamics of diversity within the teams.

5

Network Characteristics of the Project Teams

This chapter aims to present a thorough analysis of the primary network properties and a detailed network topology with the help of network metrics of both project teams. Diversity can influence the distribution of nodes and their connections, thus changing the network's structure and functionality. The impacts of diversity on each measure are investigated using network characteristics. A summary of fundamental network properties and four key network metrics —closeness, betweenness, PageRank centrality, and average local clustering coefficient— are included in the analysis. The concepts of homophily and clustering within the project team are also explored to develop a deeper understanding of the effects of diversity within the team. The chapter briefly touches on the correlation between power, influence and communication. The chapter concludes with the key findings from the results that form the basis for the expert evaluation.

5.1. Surveying and Data Preparation

The data used in this chapter was collected from a social network analysis survey built on Qualtrics, a premier surveying tool approved for collecting sensitive data by TU Delft. The survey was sent out to 46 members shortlisted from Team 1 and 25 members from Team 2 from the data obtained in the preliminary survey. The survey was made available to both teams starting in February and was fully closed out in April.

The survey sent to Team 1 received a response rate of 80.4% (36 complete responses) after cleaning the data to eliminate duplicates and incomplete responses. In comparison, the survey submitted to Team 2 received a response rate of 80% (20 complete responses), both considered good by research standards (Holtom et al., 2022). This response rate, however, is insufficient to get an unbiased view of the team's workings for a social network analysis survey (Borgatti et al., 2018). Imputation was therefore used to complete the missing data without adding any further bias.

The high levels of reciprocity in Team 2's data suggested that mean imputation would be the best technique for filling in the missing data. For Team 1, however, it was more challenging to impute missing data because the network did not show reciprocity, making mean imputation less accurate. Therefore, to fill in the missing values, multiple imputation was done in Python and IBM SPSS. The imputed adjacency matrices were compared to the actual survey data for inconsistencies and run through Gephi to ensure the imputation technique did not add any bias (Graham, 2009).

5.2. INITIAL DATA DESCRIPTION

A basic description of the two teams' network structures, including the number of nodes, edges, network reciprocity, network density, and network centralisation, is given in Table 5.1. The table in Appendix D provides a breakdown of the team members and their four network measures for both teams. 46 nodes and 898 edges formed Team 1's network, which had a 0.434 network density. With a value of 0.76, the network demonstrated moderate reciprocity, demonstrating that many connections were reciprocal. With a value of 0.487, the network was also moderately centralised, indicating that a small number of people controlled a significant portion of the information flow.

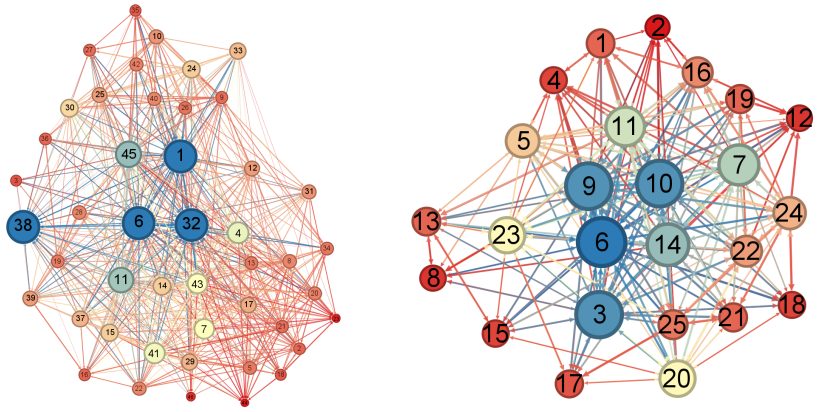
Team 2's social network has 375 edges and 25 members, giving it a higher network density of 0.625. With a value of 0.95, the network demonstrated extremely high levels of reciprocity, implying that practically all relationships were reciprocal. With a value of 0.377, the network was likewise moderately centralised, meaning few people controlled a significant portion of the information flow.

Table 5.1: Initial data description (Team 1 & 2)

Team	Number of Nodes	Number of edges	Density	Reciprocity	Degree Centralisation
1	46	898	0.434	0.760	0.487
2	25	375	0.625	0.95	0.377

Since both teams were very small, the network densities were larger, which showed that team members were more interconnected than the usual SNA datasets available for research with hundreds of nodes (Ouyang & Reilly, 2015). The reciprocity between Team 2, compared to Team 1, was substantially greater, indicating a closer-knit and more cooperative team. Both teams had moderate levels of centralisation, which showed that some people had more connections than others but not to the extent of a highly centralised network.

5.3. CLOSENESS CENTRALITY



(a) Team 1 (b) Team 2

Figure 5.1: Closeness Centralities of the Two Teams

Figure 5.1 shows the network diagram of Team 1 and 2. The colour of the nodes for Teams 1 and 2 represents the colour map of the closeness centrality for the teams, with red being the lowest closeness centrality and blue being the highest. The scores range from 0.473 to 1, with an average score of 0.650 for Team 1. The scores range from 0.558 to 1, with an average score of 0.724 for Team 2.

The data suggests that the project team is relatively well-connected, with most individuals having moderate to high values (0.473 - 1) of closeness centrality. Thus, the influence of the team members is well-balanced, which can be beneficial for collaboration and decision-making. Team 1, however, shows a slightly wider distribution compared to Team 2. This indicates some individuals with relatively low closeness centrality scores have lesser influence within Team 1. This could impact their ability to contribute effectively to the team's goals or to make informed decisions.

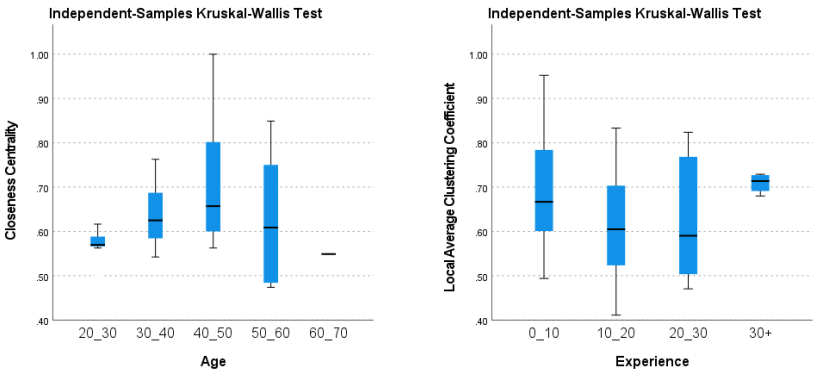
Table 5.2 gives a summary of the statistical significance of all the diversity dimensions against the closeness centrality of both Team 1 and Team 2. Closeness centrality was significantly impacted by the age group (p=0.036) of employees in Team 1, which suggests that employees in certain age groups are more closely connected within the network than others, as shown in Figure 5.2a. A post hoc Dunn Test showed that the team members between the ages of 20_30 are significantly more likely to have a lower closeness score when compared to other age groups. The mean closeness centrality increases with age groups up to the age group of 40_50 years old, after which it decreases. This is almost exactly reflected in experience diversity, as shown in Figure 5.2b, as experience characteristic shows a highly positive correlation to age characteristic (0.946). A person's

closeness centrality increases as they get older and develop greater experience in their profession. Therefore age and experience affected the influence of team members in Team 1.

Table 5.2: Statistical Significance of Diversity Dimensions against Closeness Centrality

	Team 1	Team 2
Age Groups	0.036**	0.696
Gender	0.290	0.564
Education	0.458	0.009**
Nationality	0.963	-
Experience	0.023**	0.797
Team Tenure	0.130	0.629
Location	0.990	0.648
Department	0.654	-
Organisation	-	0.956

** p<0.05 *p<0.1



(a) Age

(b) Experience

Figure 5.2: Pairwise Comparisons of Diversity Characteristics on Closeness Centrality for Team 1

Team members are more likely to be in better positions of authority within the team as they get older and their overall experience and expertise increase, thus making them more central to the network. As a result, they are closer to other team members, which

increases the closeness centrality. Thus, an individual's network of contacts in their team/ field grows wider and more diverse as they get older and gain more experience. This leads to their individual network being more closely knit and coherent, increasing their influence within the team.

In Team 2, the correlation between age or experience and closeness centrality was not found to be significant. This lack of correlation can be attributed to the team's closely distributed age and experience dimensions, skewed to the right. The median age of Team 2 is 47, while the median years of experience are 18. In comparison to Team 1, the members of Team 2 tend to be older and more experienced, which could explain why the effects of closeness centrality are less apparent in this team. This similarity in age and experience might lead to similar levels of influence and importance among the members, as measured by closeness centrality. However, an interesting finding emerged when examining the youngest members of Team 2. It was observed that these individuals had relatively low closeness centrality scores, ranking second and tenth lowest among the team members. This suggests that the younger members have lower levels of influence within the team's network.

The educational background, however, showed a significant impact on the closeness centrality of members within Team 2 (p=0.009), as shown in Figure (5.3). The pairwise comparison of the individual groups using the Poshoc Dunn Test showed that people with a master's degree are more likely to have a higher closeness centrality when compared to people with a secondary school degree and a bachelor's degree.

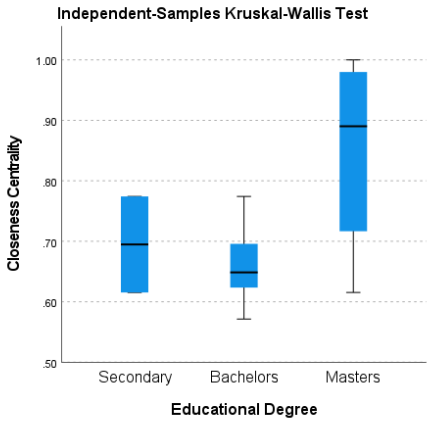


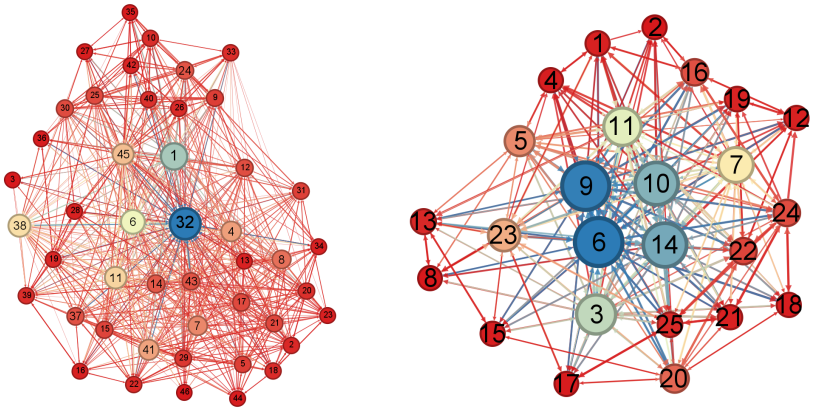
Figure 5.3: Pairwise Comparisons of Education on Closeness Centrality for Team 2

People with higher levels of education tend to have more specialised knowledge and skills, which may make them more valuable to others in the network. This can result in

more frequent interactions and collaborations with other members of the network, leading to a higher degree of closeness centrality. This is further magnified by the fact that the team itself is more focused on consultancy work, where expertise in their field plays a major role. A McPherson and colleagues (2003a) study also discovered that people with higher levels of education typically have larger and more diverse social networks.

5.4. BETWEENNESS CENTRALITY

Figure 5.4 shows the network diagram of Team 1 and 2. The colour of the nodes for Teams 1 and 2 represents the colour map of the betweenness centrality for the teams, with red being the lowest betweenness centrality, which transitions to the highest betweenness centrality shown in blue. Looking at the betweenness centrality scores for both teams, Team 1 has higher overall betweenness centrality scores compared to Team 2. Individuals with high betweenness centrality act as "brokers" or "connectors" between different groups or subgroups within a network and play a crucial role in facilitating communication and collaboration between team members.



(a) Team 1 (b) Team 2

Figure 5.4: Betweenness Centralities of the Two Teams

The top five nodes in the first team have betweenness centrality scores ranging from 0.0929 to 0.0379, while the top five in the second team have scores ranging from 0.0597 to 0.0433. Looking at the distribution of betweenness scores for both teams, Team 2 has a more even distribution of scores, with no single node having an extremely high score. In contrast, Team 1 has a more skewed distribution, with a few nodes having relatively high scores while most nodes have lower scores. This suggests that Team 1 may have a more centralised network structure, with a few key players dominating the flow of information and communication, reflected in the higher centralisation value of Team 1.

Team 1 has team members working on multiple projects simultaneously, while every member of Team 2 works on a single project. Therefore, in Team 2, the betweenness centrality is more uniformly distributed as they are required to communicate with everyone else in the team to complete tasks. The formal organisation structure of the teams can further enhance our understanding of the betweenness centrality values. In Team 1, the members report mostly to their project lead and sometimes to their department leads. This leads to a large skew in the betweenness centrality measures as the team leaders and department heads become responsible for the communication flow between the teams. Therefore, in Team 1, the members are less likely to communicate outside their individual sub-project teams themselves to get work done. This explains the skewed distribution of betweenness centrality, where team leads, and department leads are responsible for coordinating the flow of information.

Table 5.3: Statistical Significance of Diversity Dimensions against Betweenness Centrality

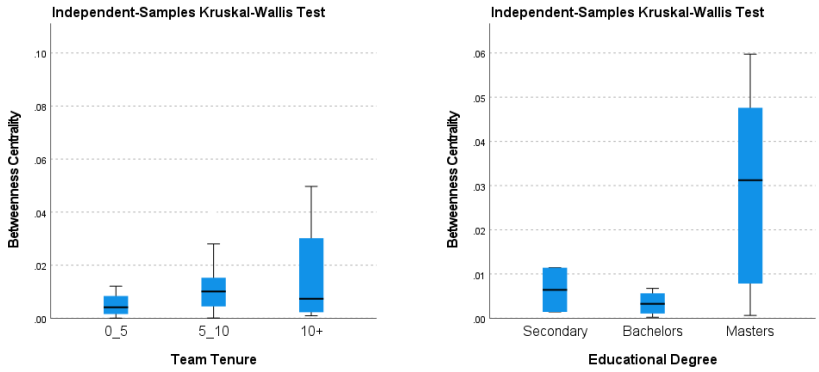
	Team 1	**Team 2**
Age Groups	0.177	0.634
Gender	0.463	0.628
Education	0.254	0.015**
Nationality	0.774	-
Experience	0.446	0.863
Team Tenure	0.091*	0.736
Location	0.551	0.619
Department	0.188	-
Organisation	-	0.89

** p<0.05 *p<0.1

Table 5.3 gives a summary of the statistical significance of all the diversity dimensions against the betweenness centrality of both Team 1 and Team 2. There was an absence of an effect of diversity characteristics on betweenness centrality for Team 1, except for a marginal significance (p=0.091) for team tenure, as shown in Figure 5.5a. Only education showed a significance for betweenness centrality for Team 2, as shown in Figure 5.5b.

The formal organisational structure of a team significantly impacts how information moves and people interact. In both teams, a formal structure already exists, intended for efficient information exchange within the network. It guarantees that essential persons or groups are well-connected to one another. This limits the visibility of the diversity dimensions on betweenness centrality in the teams. Team tenure showed marginal significance on betweenness centrality, indicating that employees with more experience

within the team may be more central to the network. The relation between team tenure and betweenness centrality suggests that it takes time for individuals to advance to positions of centrality within their teams.



(a) Team 1

(b) Team 2

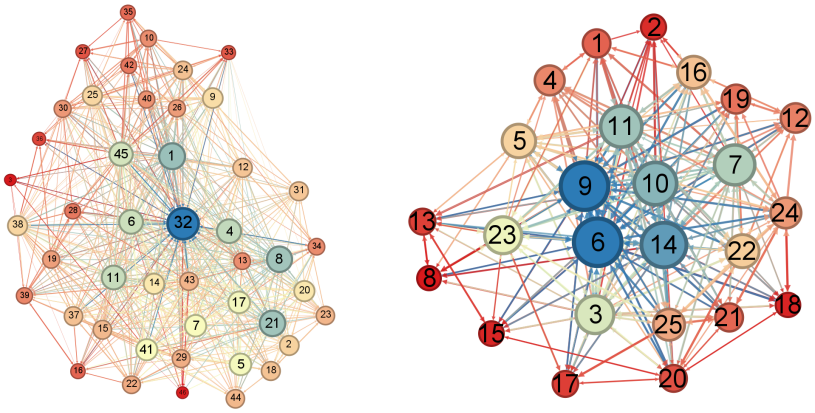
Figure 5.5: Pairwise Comparisons of Diversity Characteristics on Betweenness Centrality for Team 1 & 2

In Team 2, educational degree showed to be a significant determiner for betweenness centrality, with the top 5 members with the highest betweenness centrality all having a master's degree. A team member with a higher degree, such as a master's or PhD, generally has more in-depth knowledge and competence in a particular field, making them a critical link between team members as they become hubs of information within the network, thus connecting team members from different parts of the network. This could increase their betweenness centrality within the network and increase their significance in boosting interaction and cooperation among various team members. This effect, however, was not observed in Team 1, as Team 1 is more focused on project management and execution work. In contrast, Team 2 is more focused on consultancy work, which is more reliant on individual expertise.

In summary, apart from a very slight significance for team tenure, Team 1's diversity characteristics did not demonstrate any meaningful effects on betweenness centrality. But in Team 2, having a master's degree was a significant predictor of betweenness centrality. The formal organisational structure has an impact on how team members communicate and work together, negating some of the effects of diversity on the teams. Team 2 is more concentrated on consultancy work that relies more on individual experience, which may account for the disparity in results between Team 1 and Team 2.

5.5. PAGERANK CENTRALITY

PageRank is used to pinpoint significant/ powerful people or groups inside a social network. Figure 5.6 shows the network diagram of Team 1 and 2. The colour of the nodes for Teams 1 and 2 represents the colour map of the PageRank centrality for the teams, with red being the lowest PageRank centrality, which transitions to the highest PageRank centrality shown in blue. Team 1, with its 46 members, had page rank centralities ranging from 0.005 to 0.0476. Team 2, with 25 members, had page rank centralities ranging from 0.0710 to 0.019. The top 5 scores within Team 1 were obtained by the overall department lead and the project leads. The top 5 scores in Team 2 were obtained by the two project managers and the sub-team leads. In both teams, a large range of PageRank centrality scores was observed, with some individuals having much higher scores than others. In collaborative teams, project managers and team leads naturally possess greater authority, leading to their expected higher page rank centralities, as their roles involve overseeing and coordinating team members, and making critical decisions.



(a) Team 1 (b) Team 2

Figure 5.6: PageRank Centralities of the Two Teams

Table 5.4 gives a summary of the statistical significance of all the diversity dimensions and additional parameters against the PageRank centrality of both Team 1 and Team 2. According to the analysis of PageRank centrality, the results show that a team member's power within the project team can be significantly influenced by their location, department, and team tenure for Team 1 and their educational qualifications for Team 2, as shown in Figure (5.7).

First, it was discovered that team tenure had a slight correlation with PageRank centrality (p=0.089), indicating that those who have been a part of the team for a long time are more powerful. The increased responsibilities and importance of tasks also explain the increased PageRank centrality for individuals with longer team tenure.

Table 5.4: Statistical Significance of Diversity Dimensions against PageRank Centrality

	Team 1	Team 2
Age Groups	0.338	0.714
Gender	0.690	0.628
Education	0.634	0.015**
Nationality	0.251	-
Experience	0.503	0.955
Team Tenure	0.089*	0.839
Location	0.066*	0.659
Department	0.022**	-
Organisation	-	0.868

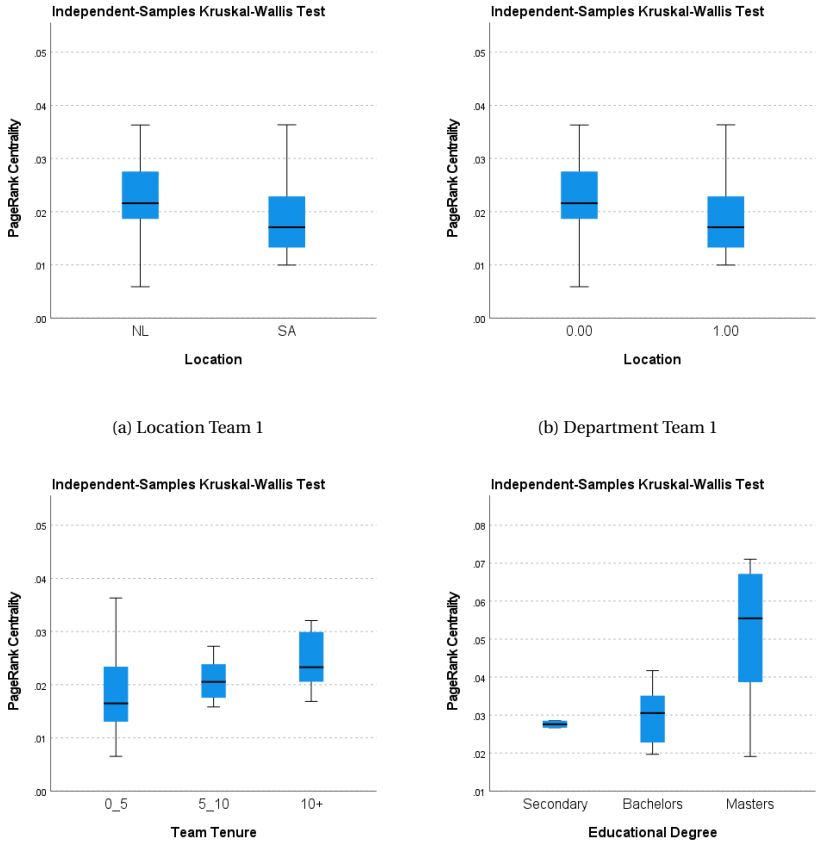
** p<0.05 *p<0.1

Additionaly, it was discovered that location correlated with PageRank centrality (p=0.066), with those working out of the Netherlands' main office demonstrating higher levels of influence and importance within the team for Team 1. This finding is corroborated by earlier research, which contends that proximity significantly impacts interaction and co-operation and can increase an individual's centrality within a social network (Borgatti & Cross, 2003).

Finally, it was discovered that the department in which they worked played a marginal role in PageRank centrality, with people from one of the departments having higher PageRank centrality than people from the other department. This outcome could be explained by this department being more actively involved in the project team's core tasks, which could result in increased opportunities for collaboration and communication (Gulati et al., 2000).

In Team 2, educational degree emerged as a significant PageRank centrality indicator. The highest educational degree acquired serves as a good measure of PageRank centrality because it is related to an individual's competence, knowledge, and experience in a certain subject, which can add to their level of power within their professional networks.

In summary, the results of the PageRank centrality analysis showed that for Team 1, a person's power inside a project team is influenced by their location, department, and team tenure. In contrast, for Team 2, their educational background can have a significant impact. For Team 2, the greatest educational degree attained is a reliable sign of PageRank centrality since it represents a person's expertise in a certain field and increases their impact and relevance in their professional networks.



(a) Location Team 1

(b) Department Team 1

(c) Team Tenure Team 1

(d) Educational Degree Team 2

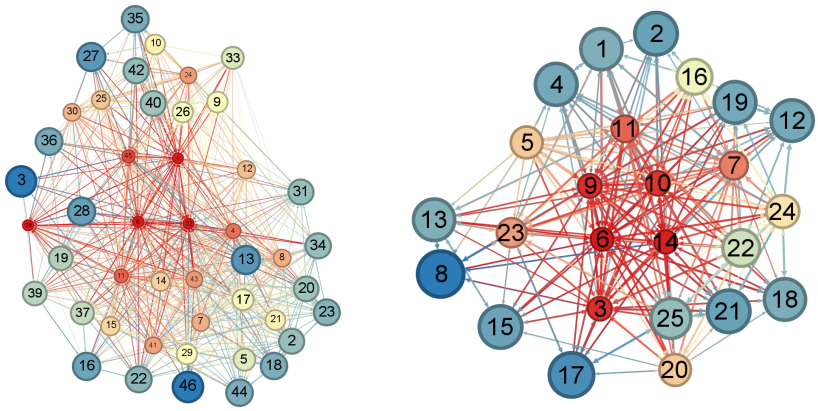
Figure 5.7: Pairwise Comparisons of Diversity Characteristics on PageRank Centrality for Team 1 & 2

5.6. LOCAL AVERAGE CLUSTERING COEFFICIENT

The local average clustering coefficient of the team members gives an indication of the network's degree of cohesion and is influenced by the diversity of nodes and connections. Figure 5.8 shows the network diagram of Team 1 and 2. The colour of the nodes for Teams 1 and 2 represents the colour map of the clustering coefficient for the teams, with red being the lowest clustering coefficient, which transitions to the highest clustering coefficient shown in blue.

The average clustering coefficient for Team 1 is 0.645, whereas the average clustering coefficient for Team 2 is 0.79. The clustering coefficients for the first team range from 0.411 to 0.952, showing a wider distribution. There are quite a few people with lower

clustering coefficients, which may indicate that some team members are less connected when compared to all their possible connections in Team 1. The clustering coefficients for the second team, on the other hand, have a smaller distribution, with values ranging from 0.592 to 0.976. Additionally, no members of the team have very low clustering coefficients, indicating that everyone is reasonably well-connected to their neighbours. Therefore, in comparison to the first team, the second team's members are more cohesive. The second team's members are also more inclined to collaborate and work on projects together, as demonstrated by the fact that they do, in fact, work on a single project, reflected in the second team's higher average clustering coefficient.



(a) Team 1 (b) Team 2

Figure 5.8: Average Local Clustering Coefficients of the Two Teams

High local clustering coefficients can be advantageous since they encourage team members to communicate and share knowledge, which improves coordination and teamwork (Girvan & Newman, 2001). This is particularly true when the tasks at hand demand a high level of dependency amongst team members and are complicated. A high local clustering coefficient, however, can also result in groupthink, as team members rely too much on the opinions and suggestions of individuals in their immediate network, possibly stifling originality and creativity. In diverse teams, it is better for its members to have a high clustering coefficient rather than a low clustering coefficient, as low clustering coefficients can lead to marginalisation within their networks. The high average clustering coefficients for both teams indicate close relationships between team members, which is positive for collaboration and team cohesion.

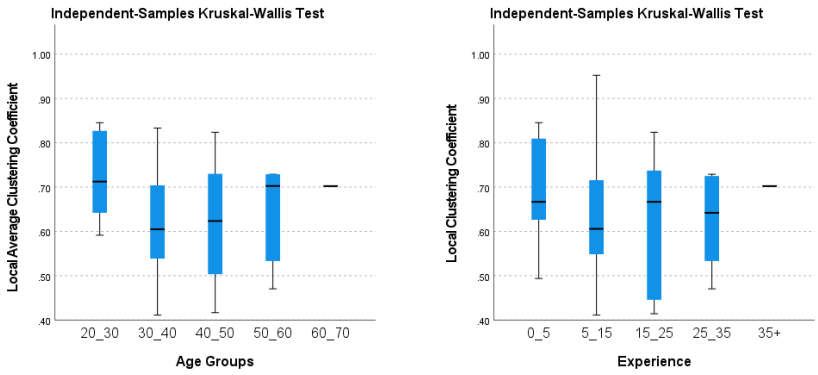
Table 5.5 gives a summary of the statistical significance of all the diversity dimensions against the local average clustering coefficients of both Team 1 and Team 2. None of the overall diversity aspects in Team 1 displayed a statistically significant link with the local average clustering coefficient. However, several sub-groups within diversity dimensions,

Table 5.5: Statistical Significance of Diversity Dimensions against Local Average Clustering Coefficient

	Team 1	Team 2
Age Groups	0.377	0.688
Gender	0.447	0.672
Education	0.345	0.012**
Nationality	0.826	-
Experience	0.704	0.866
Team Tenure	0.344	0.711
Location	0.599	0.630
Department	0.275	-
Organisation	-	0.868

** p<0.05 *p<0.1

such as age and experience, showed some significance; this was not reflected consistently throughout the sub-groups, as shown in Figure (5.9). Education was a powerful predictor of the local average clustering coefficient in Team 2.



(a) Age

(b) Experience

Figure 5.9: Pairwise Comparisons of Diversity Characteristics on Local Clustering Coefficient for Team 1

The only diversity dimension that showed a significant correlation in Team 2 is the education diversity characteristic as shown in Fig (5.10). Team members with secondary school education and bachelor's education were shown to have a higher clustering coef-

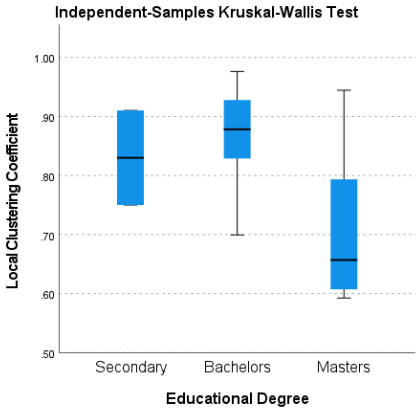


Figure 5.10: Pairwise Comparisons of Education on Local Clustering Coefficient for Team 2

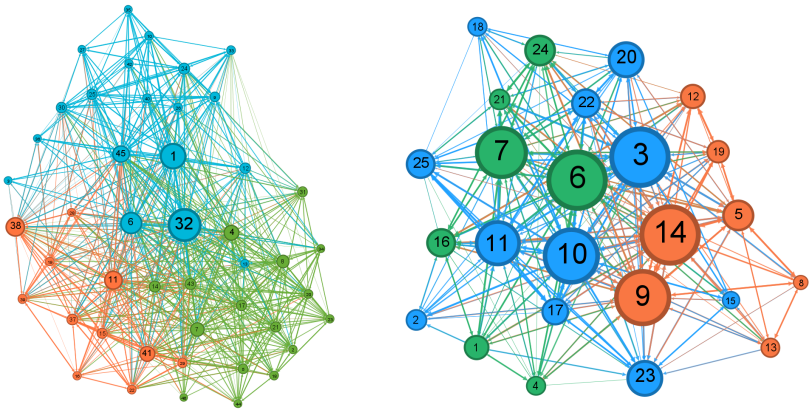
ficient, thus implying that they are more likely to form localised clusters. This can be explained by two main factors. First, team members with secondary education and bachelor's degrees worked in specialised fields compared to other team members, such as law, business, health and safety, and dyke technician, as opposed to those with master's degrees, who were involved in fields broadly related to civil engineering. This increases their high clustering coefficient, as there are only a small number of people working in these niches, with each having only 2 or 3 members. Team members who possess higher educational degrees serve as experts within their respective teams, acting as hubs of information. As a result, they are approached by other team members seeking information. However, these experts themselves tend to rely less on seeking information from others, which inadvertently leads to the formation of incomplete clusters. reducing their clustering coefficient.

The only sub-groups within Team 1 that showed any correlation were age and experience, where there was a negative correlation with local average clustering coefficient between age groups 20_30 and 30_40 with a significance of 0.055 and a similar trend between groups with 0_10 and 10_20 years of experience with a significance of 0.079. Both these trends are, however, not conclusive enough to draw conclusions from.

5.7. CLUSTERING IN THE TEAMS

This section looks into the network clustering for both teams in order to develop an understanding of how diverse characteristics could lead to clustering in the team. As shown in Figure 5.11, 3 well-separated clusters form within both Team 1 and a relatively separated cluster form in Team 2. In Team 1, the three clusters formed consist of a similar number of people, with cluster 1 (blue in Figure 5.6) having 19 people, cluster 2 (orange)

having 11 people and cluster 3 (green) having 16 people. Table 5.6 shows the individual clusters, the diversity characteristics, and the percentage of people within the cluster with specific sub-group of the diversity characteristic.



(a) Team 1 (b) Team 2

Figure 5.11: Clusters Detected using Louvain's Community Detection Algorithm

Table 5.6: Diversity characteristics present within the Clusters (Team 1)

Colour		**Blue**	**Orange**	**Green**
Cluster		**1**	**2**	**3**
Diversity Characteristic	**Sub-group**	**% total**	**% total**	**% total**
Age Group	20_30	21.1	9.1	18.8
	30_40	52.6	18.2	43.8
	40_50	26.3	45.5	12.5
	50_60	0.0	27.3	18.8
	60_70	0.0	0.0	6.3
Location	NL	26.3	100.0	100.0
	SA	73.7	0.0	0.0
Department	Dep1	36.8	54.5	31.3
	Dep2	63.2	45.5	68.8
Nationality	D	21.1	81.8	56.3
	SA	73.7	0.0	0.0

	M	5.3	18.2	43.8
Gender	Male	63.2	90.9	81.3
	Female	36.8	9.1	18.8
Experience	0_10	31.6	18.2	43.8
	10_20	47.4	36.4	31.3
	20_30	15.8	36.4	6.3
	30+	0.0	9.1	18.8
Team Experience	0_5	52.6	27.3	37.5
	5_10	31.6	45.5	25.0
	10+	15.8	27.3	37.5
Education	Secondary School	15.8	0.0	18.8
	Bachelors	63.2	27.3	56.3
	Masters	21.1	63.6	25.0
	Doctorate	0.0	9.1	0.0

The age groups are relatively well distributed among most clusters in Team 1, except for Cluster 2. There is a skew towards the older age group in this cluster, with 72.8% of the total members of Cluster 2 being older than 40. In Cluster 2 and 3, a skew towards the younger side was observed, with 73.7 % and 62.6% of the total members of Cluster 2 and 3 being younger than 40. Age is, therefore, a relevant indicator for the formation of Cluster 2 in Team 1. The gender distributions across the clusters in Team 1 remained consistent, except for Cluster 2, which displayed a notable imbalance. Approximately 91% of Cluster 2 consisted of male members.

In terms of experience diversity dimension, Cluster 2 exhibited a notable bias towards individuals with 10+ years of experience, accounting for 81.9% of the cluster. On the other hand, in Cluster 3, the percentage of individuals with 10+ years of experience was 56.3%. This indicates that when considering experience, Cluster 2 and Cluster 3 can be distinguished, while Cluster 1 did not demonstrate any significant differentiating factor in this dimension.

The nationality dimension exhibited consistent traits in predicting the composition of clusters within Team 1. Specifically, Cluster 3 demonstrated greater diversity in nationalities compared to Cluster 2, where approximately 82% of the members were Dutch in Cluster 2. Therefore, nationality can be considered a reliable predictor for distinguishing between clusters 2 and 3 in Team 1.

In Cluster 1 of Team 1, there was a higher representation of African nationalities, which aligns with the fact that the office location is in South Africa. Team 1 is based in four main offices out of Amsterdam NL, Den Haag NL, Capetown SA and Johannesburg SA. Cluster 1 showed that 68.4% of the members were in South African offices, and 26.3% were in the Netherlands. This formation of a cluster is not unusual in geographically distant teams, where physical distance might obstruct communication, collaboration, and information sharing.

In Team 2, the three clusters formed consist of a similar number of people, with Cluster 1 (orange in Figure 5.7) having 7 people, Cluster 2 (blue) having 11 people, and Cluster 3 (green) having 7 people. Table 5.7 shows the individual clusters, the diversity characteristics, and the percentage of people within the cluster with specific sub-group of the diversity characteristic.

Table 5.7: Diversity characteristics present within the Clusters (Team 2)

Colour		**Orange**	**Blue**	**Green**
Cluster		**1**	**2**	**3**
Diversity Characteristic	**Sub-group**	**% total**	**% total**	**% total**
Age Group	20_30	28.6	0.0	0.0
	30_40	0.0	18.2	14.3
	40_50	42.9	27.3	57.1
	50_60	28.6	36.4	14.3
	60_70	0.0	18.2	14.3
Location	Loc 1	28.6	27.3	14.3
	Loc 2	28.6	27.3	0.0
	Loc 3	28.6	45.5	28.6
	Loc 4	14.3	0.0	28.6
	Loc 5	0.0	0.0	14.3
	Loc 6	0.0	0.0	14.3
Organisation	Org 1	42.9	18.2	45.5
	Org 2	57.1	81.8	54.5
Gender	Male	28.6	54.5	100.0
	Female	71.4	45.5	0.0
Experience	0_10	14.3	9.1	0.0

	10_20	42.9	45.5	57.1
	20_30	42.9	27.3	28.6
	30+	0.0	18.2	14.3
Team Experience	1	57.1	18.2	0.0
	2	28.6	9.1	14.3
	3	14.3	18.2	28.6
	4	0.0	27.3	42.9
	5+	0.0	27.3	14.3
Education	Secondary School	0.0	18.2	0.0
	Bachelors	28.6	72.7	14.3
	Masters	71.4	9.1	85.7
	Doctorate	0.0	0.0	0.0

None of the diversity characteristics, except the organisation, showed a correlation for forming clusters within Team 2. However, the formal organisational structure provides valuable insights into the observed clusters. Formal organisational structures are the building blocks for organising team efforts and resources toward common goals (Kozlowski & Bell, 2003). Cluster 1 in Team 2 comprises individuals from the technical team, while Cluster 2 consists of members who focus on the environmental aspects of the project. Finally, Cluster 3 includes individuals who work on planning and architecture-related project requirements. These findings suggest that the functional backgrounds of the team members are a key diversity dimension contributing to the formation of clusters within Team 2.

5.8. ASSORTATIVITY COEFFICIENTS

The analysis revealed that the assortativity coefficient varied widely across diversity characteristics for both teams. Table 5.8 summarises the findings of the assortativity analysis for each one of the diversity characteristics for both teams. The assortativity coefficients can only be compared relatively as the coefficients vary from team to team. Based on the relative values, the assortativity coefficients are divided into low, medium and high categories. The clusters that were discovered in Section 5.7 are also included in the assortativity coefficients to help make more meaningful comparisons.

Table 5.8: Assortativity Coefficients Team 1

Diversity Dimension	Team 1	Team 2
Age Groups	-0.007	-0.072
Location	0.341	-0.038
Organisation	-	0.010
Department	0.124	-
Nationality	0.142	-
Gender	0.033	-0.060
Experience	-0.015	-0.044
Team Tenure	0.014	-0.032
Education	0.012	-0.001
Clusters	0.233	0.058

Both teams exhibited some assortativity, as seen by comparing the assortativity coefficients for Teams 1 and 2. However, the assortativity coefficients' strength and direction varied in many aspects, demonstrating that diversity exists in both teams but takes distinct forms.

There is positive assortativity for all the diversity dimensions except age and experience in Team 1. Location, Clustering, Department and Nationality showed higher values of assortativity. Location and Cluster 1 in Team 1 are considered together for assortativity as the geographical location increased the assortativity of the South African (SA) clusters to the rest of the team. An important discovery arises when comparing the assortativity between Clusters 2 and 3 located in the Netherlands. The two Netherlands (NL) clusters had the same high positive assortativity when compared to each other, as they did with the SA cluster (Cluster 1), implying that even though they are geographically closer, their assortativity was not any lower. Therefore, Clusters 2 and 3 need to be explored further.

The Nationality diversity dimension and Department showed moderate levels of assortativity. For the nationality diversity dimension, Dutch and African people made up most of the team members, and they were consistently more likely to talk amongst themselves, with Dutch – Dutch connections making 27.7% of all the bilateral connections that exist among the team members and South African – South African making up 13.8%, and the other nationalities – other nationalities connections made up about 5% of the overall edges. This implies that 47% of all the possible edges were between the 3 similar groups, and the remaining edges (53%) were divided between the other 6 group combinations, i.e., D-SA, D-M, M-SA, M-D, SA-D, and SA-M.

Gender, Education and Experience showed low positive assortativity coefficients. Therefore, they can have slight effects on the team's functioning. Among the three characteristics, gender showed the highest assortativity coefficient.

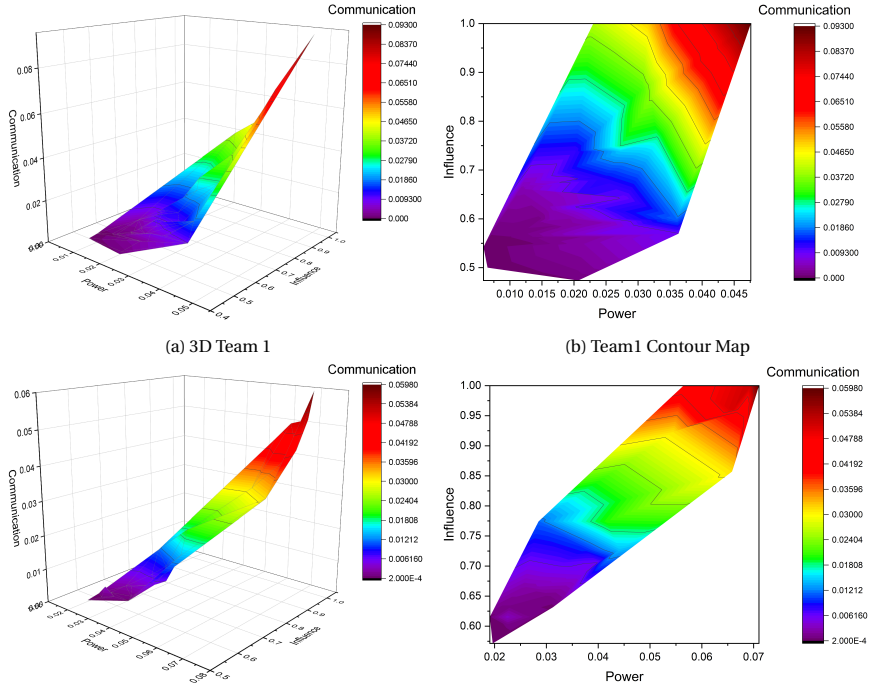
In Team 1, there is a slightly negative assortativity for age groups, which suggests that team members are less likely to work with those of a similar age. However, the strength of the effect is very minor. This trend was also reflected in the experience characteristic of Team 1, but also with a relatively weak effect.

In contrast, Team 2 exhibits a stronger negative assortativity for all the diversity characteristics except for the Organisation and Clusters, where clusters showed a low assortativity coefficient of 0.058. A lack of assortativity in Clustering for Team 2 is important, as Clusters in Team 1 showed high assortativity. Therefore, Team 2 is very disassortative, unaffected by any diversity dimensions.

The lack of significant differences in the assortativity coefficient of Team 2 is extremely surprising. Further investigation revealed that the team had previously experienced communication difficulties resolved by the project manager's efforts to increase collaboration through onboarding activities. The physical proximity of team members was also noted as a critical element in fostering collaboration and a shared identity, which was likely facilitated by the common workspace that was arranged as a part of the onboarding process. The relevance of onboarding is further explored in the expert meetings.

5.9. INFLUENCE OF FORMAL ORGANISATIONAL STRUCTURE ON DIVERSITY

A plot between power, influence and communication for both teams reveals that they are connected in both the teams as shown in Figure 5.12. The PageRank centrality, closeness centrality, and betweenness centrality are plotted along the XYZ axis. Figures 5.12a and 5.12c show the three-dimensional representation of the plot, and Figures 5.12b and 5.12d shows its 2D projections. From these graphs, we observe that at a higher level of power and influence. a linear relationship between power, influence, and communication is observed. This suggests that individuals with the greatest power and influence are also responsible for facilitating a significant portion of the team's communication. The formal organisational structure, however, heavily influences the communication channels within the network, while the diversity dimensions impact the power, influence, and clustering within the team. Therefore, by ensuring that members of certain diversity characteristics are not isolated in the team, their power and influence can be improved, and also reduce the possibilities of clustering.



(a) 3D Team 1

(b) Team1 Contour Map

(c) 3D Team 2

(d) Team 2 Contour Map

Figure 5.12: 3D Colour Map and Contour Map for the Teams

5.10. KEY FINDINGS

This section aims to summarise the key findings from the results described, which will be used as the input for the expert interviews and also answer the research sub-question 3, '**How does diversity affect the distribution of power, influence, communication and clustering within the project team?**':

- Age and Experience have been shown to significantly affect how "close/ influential" they are to the rest of the team, where members with lower age and experience are much less connected to the larger network but especially disconnected against the oldest groups (50+). The oldest groups are still quite disconnected from the middle group (30_40, 40_50).

- Education/ Functional Background played a major effect on the team when the type of work they were involved in was consultancy-based work/ work that involved experts. It showed that the power, influence, communication and clustering through team members with higher degrees were higher. Functional Background showed an effect on the clustering characteristics of the team. But this

trend was almost non-existent in the project management-based team, where education showed almost no effect on a person's importance to a team.

- There were indications of relatively high assortativity/ homophily based on Nationality where the Dutch-Dutch, South African- South African, and Misc-Misc, lines of communication, make up 47% of the communication in the overall team, when compared to other combinations in total (D-SA, D-M, SA-D, SA-M, M-D, and M-SA). Gender also affected homophily, although it was 4 times weaker than nationality. In line with this, it was also observed that one of the clusters in Team 1 had members who were predominantly Male (91%) and Dutch (82%) and made up 72.8% of people over the age of 40.

- Onboarding/Extracurricular activities can play a major role in how much the effects of diversity itself are reflected in the project teams. A comparison between Team 2 and Team 1 showed that Team 2, where significant effort was taken to ensure everyone bonds, showed lower variations in network characteristics based on diversity characteristics.

- It was observed that diversity affects most of the Power, Influence, and Clustering/ Assortativity. In contrast, the formal organisational structure affects the flow of communication (Betweenness), where who reports to whom affects the flow of communication. The formal organisational structure can, however, influence the power, influence and clustering within the team. The formal organisational structure can ensure members of certain diversity characteristics are not isolated, thus improving their power and influence and reducing the possibilities of clustering.

5.11. CONCLUSION

This chapter aimed to understand the basic network characteristics of the two project teams and understand the relationship between the network characteristics and the diversity dimensions, and thus understand how the team dynamics are possibly affected by diversity characteristics. A Kruskal Wallis-H test was used to determine the statistical significance of the relationship between diversity dimensions and network characteristics.

The findings of this chapter reveal interesting insights regarding the impact of diversity on basic network metrics within the two project teams. In Team 1, age groups significantly influenced closeness centrality, with younger team members exhibiting lower scores compared to other age groups. As age and experience increased, closeness centrality also increased until reaching a plateau in the 40-50 age group. In Team 2, educational background significantly influenced closeness centrality, with individuals holding a master's degree exhibiting higher scores compared to those with a secondary school or bachelor's degree. This finding suggests that individuals with higher levels of education possess specialised knowledge and skills, making them valuable collaborators within the network.

Diversity showed limited effects regarding betweenness centrality, except in Team 2, where educational background played a significant role. Team members with master's degrees demonstrated higher betweenness centrality, acting as critical links connecting individuals from different parts of the network. This highlights the importance of individuals with higher degrees who possess in-depth knowledge and serve as hubs of information exchange within the network.

Furthermore, the analysis of PageRank centrality indicated that, in Team 1, additional parameters such as location, department, and team tenure influenced a person's power within the project team. In contrast, in Team 2, educational background, specifically the highest degree attained, significantly impacted PageRank centrality, reflecting a person's expertise and increased impact in their professional networks.

Homophily and clustering characteristics of the network provide deeper insights into the effects of diversity on project teams. The clustering of Team 1 was analysed based on age, nationality, experience, gender, and education diversity characteristics. Organisation, location and departments were the additional parameters that were studied. Age and location were strong predictors for forming clusters, with Cluster 2 having a skew towards older members and being based entirely in the Netherlands. Cluster 3 had a skew towards younger members and was based entirely in South Africa. Department also played a significant role in forming clusters, with Cluster 2 being predominantly made up of members from one department and Cluster 3 being almost entirely made up of members from another department. Nationality, experience, gender, and education did not show consistent traits in predicting the formation of clusters.

The results suggest that diversity characteristics have different impacts on the homophily within teams, with some characteristics leading to stronger homophily than others. In team 1, Nationality and gender showed significant positive assortativity. The other diversity characteristics, such as experience, team tenure and education, seem to play a far smaller role in the homophily of the network. This knowledge can be used to develop strategies to increase collaboration within the project team, thus facilitating smoother communication across its diverse members.

The observed clusters are related to the functional background of the team members. Cluster 1 comprises technical team members, Cluster 2 consists of environmental-focused members, and Cluster 3 includes individuals who work on planning and architecture-related project requirements. Team 2 showed a low assortativity coefficient for all diversity characteristics except organisation and clusters, indicating that diversity did not play a significant role in team formation. This lack of clustering and homophily based on diversity dimensions in Team 2. Further investigation revealed that efforts to increase communication and collaboration between the two organisations could have reduced the impact of diversity on team dynamics.

6

Expert Evaluation

In order to gain practical insights and expert perspectives on fostering collaboration in diverse teams, this chapter presents the findings from expert interviews. Building on the conclusions drawn in the previous chapter regarding the significance of diversity and its impact on the social structure, these interviews aim to understand the effects. The insights derived from these expert interviews will contribute to bridging the gap between theory and practice, offering valuable recommendations to strengthen collaboration within diverse project teams. Appendix E provides comprehensive information concerning the process of expert selection and the interview structure.

6.1. Key Themes Discussed and Findings

The key themes discussed with the experts were based on the conclusions drawn from Chapters 5. The conclusions and their corresponding discussion with the experts are as follows.

6.1.1. Age, Experience and Connectedness

This conclusion is based on the significance of age and experience on the closeness centrality of the team members. It showed that age and experience significantly affected how 'close/ connected' a team member was to the rest of the team. Members of the team with lower age and experience (20-30 years of age and 0-10 years of experience) were much less connected to the rest of the team but especially disconnected against the oldest groups (50+ years in age and 30+ years in experience). It was also noted that the oldest groups were still relatively disconnected from the middle age groups (30-50 years and 10-30 years of experience).

PM1 confirmed the findings and hypothesised that it was probably because of the career path of the team members that such an effect was observed. He observed that the average person's career goes up in terms of the importance of the work as they are

older and more experienced, reaching a peak when they're somewhere between 30-50 years old and then going down as they become older than 50+. He noted this change with a comparison to their transition from operational to strategic roles. He also noted that the middle group was usually at the pivotal point in this transition, thus becoming very central to the organisation from a social network point of view. He observed that the younger team members with little experience who join the team after their education are automatically on the fringes of the team as they slowly build connections over time. The older team members older than 50 and with more than 30+ years of experience move from a central position within the team to the fringes of the project team as they close retiring.

PM2 acknowledged the presence of a "disconnect" between the youngest and oldest team members yet initially failed to discern a notable gap between the youngest and middle age groups. PM2 posited that individuals within the same age groups shared a common "language," implying a disparity in communication styles stemming from generational differences. PM2 hypothesised that the effortless nature of intra-generational communication could be the key factor contributing to this phenomenon. Following a further inquiry into the observed "disconnect" between the youngest team members and the middle age groups, PM2 surmised that this effect could potentially stem from the limited scope of the network that team members initially possess upon joining a project. Initially, their understanding of the network is confined to the parameters of their own project. However, as time progresses, they begin to observe interactions and exchanges among other team members, gradually making sense of the complete team network that provides them with a broader comprehension of the overall team.

PM1's interpretation raised a crucial question regarding the underlying factors contributing to the observed phenomenon. Specifically, it explored whether the aforementioned reasoning primarily stemmed from career growth alone or was influenced by the senior team members becoming experts in their respective fields. Furthermore, it investigated whether these experts naturally transitioned to more technical roles, thereby moving away from their previous responsibilities of facilitating communication. The response to this question was rather mixed from PM1; he felt that the experts are usually hubs of information, implying that they would have a lot of information flow through them and be in higher positions of authority.

A weighted measure known as In-degree centrality and Out-degree centrality gives additional insights into the information flow among the team members under investigation. A disparity emerges when comparing the in-degree centrality to the out-degree centrality values for the more experienced team members. This discrepancy suggested that many individuals sought information from these experts, while the experts approached fewer individuals for information, leading them to be on the fringes of the team.

PM1 proposed a valuable recommendation to enhance team collaboration. It was emphasised that the experts should recognise the inherent limitation of possessing expertise solely within a single field. Acknowledging the interdependent nature of projects,

it was suggested that no undertaking could typically be accomplished solely through the application of a single area of expertise. Therefore, the experts should be encouraged to proactively engage in collaborative efforts with their teammates to broaden their perspectives. By doing so, they would enrich their problem-solving approaches and enhance the quality of their expert solutions.

6.1.2. IMPORTANCE OF ONBOARDING AND ITS EFFECTS ON DIVERSITY

This conclusion was based on clustering and homophily measures mentioned in Chapter 5, where it was observed that onboarding could play a major role in how much the effects of diversity itself are reflected in the project teams. A comparison between Team 2 and Team 1 showed that Team 2, where significant effort was taken to ensure everyone bonds, showed lower variations in network characteristics based on diversity characteristics.

PM1 and PM2 confirmed the findings and acknowledged the time it takes for a team to become a team rather than a group of people working together. In doing so, PM1 underscored the pivotal role of trust in the team-building endeavour. Drawing a parallel to Tuckman's (1965) forming-storming-norming-performing model, which explains the sequential stages of team development, PM1 highlighted the relevance of this framework. However, PM1 expressed concern regarding the inadequate attention organisations typically allocate to this process, noting a prevailing reactive rather than proactive approach to onboarding. This observation aligns with the experiences encountered by the second team, further emphasising the need for a more concerted and deliberate approach to fostering team collaboration through onboarding.

PM2 underscored the significance of implementing a distributed onboarding approach consisting of multiple shorter sessions spread over an extended duration, in contrast to a condensed single session at the onset. PM2 posited that such an approach holds the potential to enhance the efficacy of the onboarding process substantially. PM2 placed considerable emphasis on the quality of the onboarding process, asserting the necessity of allocating dedicated time specifically for onboarding activities rather than incorporating them amidst regular work responsibilities. PM2 recognised the importance of onboarding sessions for the younger team members to build new connections within the organisation.

Efforts directed towards cultivating collaboration within diverse teams are of particular significance, especially when confronted with increased diversity where variations in mindsets become more prominent. Ensuring an effective flow of information within the network is crucial to prevent the isolation of specific diversity sub-groups. It is important to recognise that expediting the collaborative process can be facilitated through a dedicated focus on onboarding. Still, it is equally essential to acknowledge the inherent limitations in the speed at which teams progress through the forming, storming, norming, and performing phases. Project managers should demonstrate awareness of

this dynamic and allocate sufficient time accordingly. Additionally, recurring onboarding activities, particularly when new team members join, play a vital role in facilitating their assimilation into the team and fostering integration within the network. This is especially crucial for younger, less experienced team members, as it strengthens their connections within the network and enhances overall team collaboration.

Another noteworthy aspect raised by PM1 in relation to the project phases related to the significance of replicating this process during the transitional points from one phase to another, such as the transition from the design to the construction phase of a project. Onboarding practices gain particular relevance when considering the functional backgrounds of team members, as a transition between phases may involve the introduction of new individuals with diverse functional backgrounds. Thus, ensuring their integration with the existing team becomes crucial. By emphasising the importance of onboarding during these transitional phases, the team can effectively assimilate new members and enhance collaboration within the overall team structure.

6.1.3. THE ROLE OF EDUCATION AND FUNCTIONAL BACKGROUND

Education/ Functional Background played a major effect on the team when the type of work they were involved in was consultancy-based work/ work that involved experts. It showed that the power, influence, and communication through team members with higher degrees were higher. Functional Background showed an effect on the clustering characteristics of the team. But this trend was almost non-existent in the project management-based team, where education almost did not affect a person's importance to a team.

PM1 expressed surprise at the finding that education and functional background can be a significant factor in a person's importance within a team. However, PM1 believed that it would be challenging to observe education and functional background as prominent predictors within a well-structured team that comprises individuals from both technical and management backgrounds. In support of this view, PM1 referred to Belbin's team roles model, emphasising its importance in establishing a balanced team (Belbin, 2010). PM1 highlighted the necessity of having individuals with technical expertise managed by team members who possess strong interpersonal skills, acting as social lubricants to align everyone's goals towards the project, thereby enhancing collaboration. To illustrate his point, PM1 used the example of constructing a bridge, illustrating that no single individual is capable of completing all aspects of the construction alone. Instead, it is crucial to have team members responsible for designing the bridge, procuring materials, creating schedules, and so on. In such a team, PM1 argued that educational or functional background would not serve as the primary indicator of power, influence, and communication dynamics. PM2 did not recognise the effect of education on the team either and could not provide any explanation to explain the observed effect.

6.1.4. NATIONALITY AND GENDER ON CLUSTERING AND HOMOPHILY

It was observed that there were indications of relatively high assortativity/ homophily based on Nationality where the Dutch-Dutch, South African- South African, and Misc-Misc, lines of communication, make up 47% of the communication in the overall team when compared to other combinations in total (D-SA, D-M, SA-D, SA-M, M-D, and M-SA). Gender also affected homophily, although it was 4 times weaker than nationality. In line with this, it was also observed that one of the clusters in Team 1 had members who were predominantly Male (91%), and Dutch (82%) and made of 72.8% of people over the age of 40.

Both PM1 and PM2 promptly identified this phenomenon within the project and arrived at a strikingly similar explanation regarding its underlying causes. PM1 and PM2's initial view focused on the potential influence of cultural and language barriers as key contributors to the observed disparity. Emphasising the significance that native languages can play in team communication, they highlighted how individuals often feel more at ease and comfortable when expressing themselves in their mother tongue compared to using English as a common second language, which is typically the case for many members of the project team in the Netherlands. They also acknowledged that variations in dialect and speaking style across different countries could introduce additional contextual complexities even within English.

Cultural disparities were identified as potential sources of diverse expectations regarding communication styles, body language, and specific contexts. The language barrier this brings was recognised as a particularly potent factor capable of impacting even the most internationally diverse teams that diligently strive to operate in a unified language. In contrast, PM1 suggested that gender-based communication played a relatively smaller role. The belief was expressed that communication between individuals of different genders but the same nationality or native language is likely to encounter fewer barriers than communication between individuals of the same gender but different nationalities or languages. This analysis highlights the multifaceted influence of cultural and language dynamics on communication patterns within the team.

Regarding the gender homophily effects, PM2 suggested that divergent patterns in informal conversations between men and women could potentially account for the existence of homophily. PM2 posited that dissimilar interests in informal discussions between genders might contribute to this phenomenon. However, PM2 also acknowledged that the impact of gender homophily is notably less pronounced compared to the influence of nationality, a finding similarly recognised by PM1.

The phenomenon of cluster formation with distinct diversity characteristics could be attributed to several factors. During an interview, PM1 highlighted the "hourglass effect" in age distribution within organisations, referring to a pattern where employees tend to experience a career shift approximately seven years into their tenure within a

single organisation, which he called the '7-year itch'. This effect contributes to an uneven distribution of employees across age groups, resulting in a relatively larger number of individuals in both the younger and older age brackets, with a lower number of members in the middle age groups. Furthermore, PM1 suggested that disconnection between the younger and older age groups may contribute to the observed clustering.

Moreover, PM1 proposed that the formation of the identified cluster, predominantly consisting of male members of Dutch nationality over the age of 40, could be influenced by the retirement of approximately half of their connections over time. This retirement-induced disconnection, combined with their lower number of connections with the narrower section of the hourglass and high disconnection from the younger age groups, might encourage the formation of more cohesive clusters. Additionally, specific past projects involving Dutch clients and the requirement for Dutch documentation could have further reinforced the need for pure Dutch teams at that point, potentially contributing to the observed clustering phenomenon. These various factors provide plausible explanations for the formation of clusters characterised by specific diversity attributes within the department. But, he also alluded to the importance of avoiding these tendencies in teams, as the formation of such clusters will hinder collaboration in the team.

6.1.5. INTERPLAY BETWEEN DIVERSITY, ORGANISATIONAL STRUCTURE, AND INFORMATION SYMMETRY

The analysis revealed that diversity notably impacts certain network characteristics, namely Power, Influence, and Clustering/Homophily. In contrast, the formal organisational structure primarily influences the flow of communication, as indicated by Betweenness Centrality. Specifically, the hierarchical relationships (who reports to whom) within the organisational structure determine the channels through which communication flows, while diversity itself has a comparatively limited direct influence on this aspect. However, it is important to recognise the potential indirect relationship between the formal organisational structure and Power, Influence, and Clustering/Assortativity. The formal organisational structure could play a vital role in mitigating the isolation of individuals with specific diversity characteristics within the network.

The formal structure can enhance their power and influence within the organisation by ensuring that members of diverse backgrounds are not marginalised. Furthermore, by fostering inclusivity and reducing the likelihood of clustering, the formal structure contributes to a more balanced distribution of power and influence among individuals. PM1 raised a crucial point regarding the potential root cause of marginalisation within the network, highlighting information asymmetry as a key factor to address. Ensuring equitable access to information becomes paramount in preventing such marginalisation. However, PM1 also noted that modern teams have embraced flatter organisational structures with digital advancements, which have democratised information within teams. This democratisation of information, in turn, aims to reduce disparities that might have previously existed.

PM2 raised an important point emphasising the significance of promoting diversity at the organisational level rather than solely at the team level. PM2 contended that if the formal organisational structure fails to proactively integrate diversity, the responsibility for ensuring inclusion and avoiding marginalisation of certain groups falls upon the teams themselves. While an ideal scenario would entail universal openness to diversity without any issues, the reality is that not everyone is aligned with this objective. Hence, it becomes crucial for the formal organisational structure to actively safeguard against the marginalisation of diversity within the organisation.

The empirical data supports PM1's assertions, as it revealed that even members positioned at the fringes of both teams had swift access to information. Notably, the average path between any two team members was less than 1.5 individuals, affirming the efficient dissemination of information in both teams. PM1 emphasised that information symmetry assumes particular significance in diverse teams due to the heightened vulnerability to marginalisation. Thus, the focus should extend beyond mere diversity and prioritise inclusivity within project teams. These findings highlight the importance of equal access to information in mitigating disparities and fostering inclusive dynamics within teams. The digitisation of processes has also played a pivotal role in achieving information symmetry, promoting collaboration, and minimising the chances of marginalisation. Organisations can enhance team collaboration, knowledge sharing, and overall performance by acknowledging the need for diversity and inclusivity.

Thus, although diversity may not directly impact the flow of communication through the organisational structure, its placement within the formal organisational structure can influence the levels of Power, Influence, and Clustering/Homophily dynamics within the team, thus emphasising the importance of considering both factors in understanding the network characteristics within the department. With careful optimisation to reduce information asymmetry in projects, the positive effects of diversity can be maximised.

6.2. STRENGTHENING THE SOCIAL NETWORK AND COLLABORATION

Based on the information presented in this chapter, it is evident that collaboration can be improved in diverse teams by implementing the following strategies:

- **Reforming onboarding practices: -** Organisations should prioritise effective onboarding processes that facilitate trust-building, team bonding, and integration of new members. Attention should be given to individual assimilation and team development, recognising the time required for a team to transition from a group of individuals to a cohesive unit. To maximise the effectiveness of onboarding efforts, it is important to distribute them across an extended timeframe while allocating dedicated time specifically for this purpose. This approach ensures optimal outcomes by allowing sufficient duration and attention to the onboarding process.

It is crucial to establish clear communication channels and protocols to ensure that new team members have access to essential information and resources. This can involve providing comprehensive project documentation, outlining roles and responsibilities, and introducing new hires to key stakeholders.

- **Embracing diversity and inclusivity:** - Cultivating collaboration within diverse teams is essential for harnessing the power of different perspectives and mindsets. When individuals from various backgrounds come together to work towards a common goal, they bring unique insights, experiences, and skills that can lead to innovative solutions and better decision-making.

  To foster collaboration, it is crucial to recognise and value the different perspectives and mindsets present within the team. This involves creating an inclusive environment where everyone feels heard, respected, and empowered to contribute their thoughts and ideas. By actively seeking out and appreciating diverse viewpoints, team members can learn from one another, challenge their own assumptions, and gain a more comprehensive understanding of complex problems. This not only leads to better outcomes but also promotes a sense of belonging and cohesion within the team.

  Equal access to information plays a vital role in cultivating collaboration and preventing the isolation of specific diversity sub-groups. When information is shared transparently and inclusively, it eliminates information asymmetry and ensures everyone has access to the same knowledge and resources. This helps to level the playing field and creates a sense of fairness and equity within the team. Additionally, by avoiding information silos and promoting open communication, organisations can break down barriers and encourage collaboration among diverse team members, enabling them to work together more effectively towards shared goals.

- **Encouraging interdisciplinary collaboration:** - In consultancy-based work, where expertise is crucial, experts should be encouraged to engage in collaborative efforts with teammates from different functional backgrounds. Construction projects involve numerous complexities and interdependencies, making it crucial to leverage diverse expertise. By engaging in collaborative efforts, experts can broaden their perspectives and gain a more comprehensive understanding of the project.

  This collaborative approach enriches problem-solving approaches by integrating various viewpoints and harnessing the collective intelligence of the team. Furthermore, collaborative efforts within construction teams enhance the quality of expert solutions. By combining expertise from different functional backgrounds, the team can identify and address potential issues more effectively. Each expert contributes their specialised knowledge. The diverse perspectives and insights from the collaborative process result in robust solutions that consider a broad range of factors and minimise blind spots. Through teamwork and mutual respect, construction teams can leverage their expertise to deliver high-quality solutions that meet client requirements and industry standards.

- **Addressing cultural and language barriers:** - Organisations should be aware of the potential impact of cultural disparities and language barriers on team com-

munication. Just awareness of these effects alone can greatly improve the quality of communication in teams. his heightened awareness fosters an environment where team members actively seek clarification, listen attentively, and ensure that their messages are conveyed clearly. As a result, communication breakdowns can be minimised, leading to improved efficiency, productivity, and overall project outcomes.

Providing support and resources to overcome these barriers, such as language training and promoting a culture of inclusivity, can further improve collaboration within diverse teams. By investing in language training, organisations enable individuals to communicate more effectively, reducing the likelihood of misunderstandings and promoting a more cohesive and collaborative team environment. Additionally, promoting a culture of inclusivity within construction teams encourages open and respectful communication among all members, regardless of their cultural or linguistic backgrounds. This inclusive culture fosters trust, encourages diverse perspectives, and improves teamwork, ultimately leading to better decision-making and project success.

- **Considerations while building the formal organisational structure: -** The formal organisational structure exerts a greater impact on the communication flow within an organisation, while diversity dimensions primarily affect power dynamics, influence, and clustering. The formal organisational structure plays a crucial role in mitigating the adverse effects of diversity on power, influence, and clustering by preventing information asymmetry. Organisations should strive for a formal structure that promotes inclusivity, minimises marginalisation, and ensures an equitable distribution of power and influence among team members. In an ideal scenario, the responsibility to avoid marginalising certain diversity dimensions within a team could be entrusted to the team members as they organise and collaborate. However, in reality, not all team members may be aligned with this objective. To prevent the marginalisation of diversity characteristics, it is essential to integrate diversity at the organisational level by incorporating it across project teams rather than confining it solely to specific teams.

6.3. CONCLUSION

The excerpt presents findings and insights from expert interviews on age, experience, connectedness, onboarding, education/functional background, nationality, gender, and the influence of formal organisational structure on information flow in diverse teams. The analysis highlights the impact of age and experience on team connectivity, with younger and less experienced members being less connected to the team. The importance of onboarding is emphasised, as it plays a crucial role in team collaboration and reducing variations based on diversity characteristics. Education and functional background were found to affect team dynamics in consultancy-based work significantly but not in project management-based teams. Cultural and language barriers were identified as influential factors in team communication, with nationality exhibiting higher assortativity than gender. The formal organisational structure was important in mitigating

isolation and ensuring equitable access to information.

The chapter then gives specific recommendations to strengthen collaboration within diverse teams, which then answers the fourth sub-research question, '**How can collaboration within the diverse project team be strengthened?**'. Firstly, organisations should prioritise effective onboarding processes that focus on trust-building, team bonding, and the integration of new members, allowing sufficient time for the team to transition from individuals to a cohesive unit. Embracing diversity and inclusivity is crucial, with efforts directed towards cultivating collaboration among team members from different backgrounds, valuing diverse perspectives, and ensuring equal access to information to prevent the isolation of specific sub-groups. Encouraging interdisciplinary collaboration, particularly in consultancy-based work, enhances problem-solving approaches and the quality of expert solutions. Addressing cultural and language barriers is essential, as awareness alone can significantly improve team communication while providing support and resources, such as language training and promoting an inclusive culture, further enhancing collaboration. Additionally, consideration should be given to the formal organisational structure, aiming for inclusivity, equitable distribution of power and influence, and reducing marginalisation. By implementing these strategies, collaboration within the project team can be strengthened, fostering a harmonious and productive working environment.

7

DISCUSSION

This chapter discusses the research findings and concludes by addressing the limitations of the research.

7.1. ADDRESSING THE MAIN RESEARCH QUESTION

Managing diversity has become crucial for improving collaboration in organisations because it leads to enhanced innovation, adaptability, problem-solving, decision-making, and employee engagement and meets the expectations of diverse stakeholders (Hunt et al., 2015). This research is an exploratory study aimed at exploring the effects of team diversity on the social structure of a project team. The main research question is, "*What are the effects of diversity on the social structure of construction project teams?*".

The findings of this study suggests that diversity exerts adverse effects on the social structure of a project team, as demonstrated by its detrimental impact on the distribution of power, influence, communication, and clustering tendencies. Age and experience affected the influence that team members had within the team, while education affected the power, influence and communication patterns within the team. Nationality, gender and functional background increased the tendency of clustering and the formation of similarity-based connections. The research delved into the potential avenues for mitigating the adverse impacts associated with diversity, aiming to maximise the advantages it offers. Reforming the onboarding process, embracing diversity and focusing on inclusivity, encouraging interdisciplinary collaboration, addressing cultural and language barriers and taking diversity into consideration while building the formal organisational structure are recommended.

7.2. DISCUSSION OF THE RESULTS

The results found that age and experience significantly affected the influence of team members. Younger and less experienced members were less connected to the rest of the team than the oldest members. The oldest members were also relatively disconnected from the middle-aged group. Existing literature already talks about the expertise of the team members being an important determinant for the influence of team members, and older and more experienced team members are often experts in their field (Kozlowski & Ilgen, 2006). Other literature has also talked about how older and more experienced team members are also perceived to be more trustworthy, which increases their influence within the team (Brown et al., 2012).

A noteworthy and unexpected discovery derived from this research pertains to the pattern of influence within teams in relation to age. In contrast to prevailing literature suggesting that the highest levels of expertise and influence are typically associated with the oldest and most experienced groups, this study revealed a distinctive trend. Specifically, the analysis demonstrated a peak followed by a decline in influence after the middle age groups, challenging the prevailing understanding. Subsequent examination of this finding elucidated the pivotal role played by team members' transition from operational to strategic roles in shaping their influence. In addition to expertise, the influence of team members was found to be intricately linked to their position at the pivot of this transition. Notably, the most influential individuals were situated precisely at this pivotal point, emphasising the salience of this role shift in determining their influence within the team. There are multiple benefits to increasing the influence of the younger members of the team, such as increased innovation, technological expertise, adaptability, enthusiasm and a willingness to learn (Adyaribowo et al., 2023; Briker et al., 2021). Therefore, it is important to reduce this gap in the influence of the youngest members.

Talking about expertise and its role in influence within the team, educational background showed to be a consistent predictor of the power, influence and communication patterns within a diverse project team when their work focused on consultancy-based or work that required experts. This is because their education and expertise can provide them with a deeper understanding of the subject matter, which can be valuable in decision-making and problem-solving within the team (Greaves & Bradberry, 2014). Additionally, their expertise can give them credibility and respect among their peers, which can increase their influence within the team.

However, it is important to note that expertise alone is not enough to guarantee to improve a team member's power, influence, and communication. Effective communication, leadership abilities, and emotional intelligence are important factors in determining one's power and influence within a team, which could be one of the reasons the experts' interview failed to recognise this effect (Kozlowski & Ilgen, 2006).

The study revealed high similarity-based clustering on nationality and gender within the project team, while clustering based on the functional background was also ob-

served. Cultural and language barriers were identified as potential factors contributing to the observed disparities. Native languages were seen as playing a crucial role in communication, as individuals often feel more comfortable expressing themselves in their mother tongue rather than using English as a common second language. Dialect and variations in speaking style within the English language are recognised as potential sources of additional complexities. Existing literature matches this view and shows individuals from the same nationality are more likely to associate with each other due to their shared cultural norms, values and experiences (Békés et al., 2022). Studies on this effect based on gender found that this could be occurring due to shared experiences and perspectives related to gender. They may also be influenced by gender stereotypes and biases (Campero & Kacperczyk, 2020).

In terms of functional background and its effects on clustering, expertise and power centralisation can explain the effects. A team member's functional background that provides valued expertise will be associated together in their decision-making process, especially in relatively centralised teams like the ones studied in this research. This leads to the clustering of team members with similar expertise or functional backgrounds. Therefore, in centralised teams, team members with similar functional backgrounds are more likely to be involved in decision-making, leading to clustering (Bunderson, 2002). This can have negative impacts, such as limited perspectives and lack of innovation within the team and, therefore must be mitigated as much as possible.

The diversity dimensions that affected clustering (i.e. nationality, gender and functional background), however, showed little to no effect on the power, influence and communication characteristics of the team, which is rather surprising, as literature has shown previously that clusters that form in the team due to diversity dimensions such as nationality and gender usually lead to some form of marginalisation within the network (Villesèche et al., 2020). This was, however, not observed at all in the project teams studied, and the flat organisational structure that is commonplace in the Netherlands could be attributed to this effect. A flat organisational structure delegates power and influence throughout the network, leading to smaller chances of the power being concentrated into particular clusters (Reitzig, 2022).

The analysis brought attention to the significance of onboarding processes in reflecting the impact of diversity within project teams. Teams that made deliberate efforts in onboarding exhibited less variation in network characteristics based on diversity attributes. While existing research already demonstrates the benefits of onboarding on teams, it is an aspect that is frequently overlooked or inadequately addressed in the industry (Kyriakou, 2022; Moe et al., 2020). Moreover, this study reveals the importance of adopting a proactive approach to onboarding rather than a reactive one, as a reactive approach often proves insufficient, as evidenced in one of the observed teams. This study also highlights the importance of a distributed onboarding approach with multiple shorter sessions spread over a longer period. Recurring onboarding activities, particularly for new team members, play a vital role in assimilation within the team, especially for the younger team members.

The interplay between power, influence and communication within the team is an important result. Individuals who possess power within the team often exert a notable level of influence while also assuming the responsibility of facilitating communication between sub-groups that would otherwise struggle to engage in dialogue with each other. French and Raven's (1959) bases of power provide an explanation for this effect. Connecting the power, influence, and communication patterns of members in a team using this framework involves analysing how team members use the six bases of power (legitimate, reward, coercive, referent, expert, and information) to influence others and how this affects communication patterns. The same sub-set of people often hold the most power, influence and communication within the team because they are perceived to have the most expertise, reputation, or authority based on position, which gives them referent, expert, coercive and legitimate power, improving their status within the team. They are also more likely to bring people from different parts of the network to get things done, thus giving them information power.

Diversity significantly affects the network characteristics such as power, influence, and clustering/homophily, while the formal organisational structure primarily influences communication flow. The hierarchical relationships within the structure determine communication channels, while diversity has a limited direct influence on this. However, the formal structure can indirectly isolate individuals of specific diversity characteristics, thus influencing their power, influence, and clustering/assortativity. Information asymmetry's impact on marginalisation has been extensively examined from a political perspective (Warschauer, 2018). This research explores its implications within a construction project team. It reveals that marginalisation among team members can also stem from disparities in information access, underscoring the critical need for equitable distribution of information. Modern teams adopting flatter structures and digital advancements have democratised information, reducing disparities. The empirical data demonstrates that quick access to information, even for peripheral team members, ensures that information symmetry in project teams is significant in the effects of diversity on the team.

The study highlights the importance of promoting diversity at the organisational level rather than solely concentrating on diversity within teams. It argues that if an organisation's formal structure does not proactively embrace diversity, the responsibility falls on the teams to ensure inclusion and prevent the marginalisation of specific groups. While the ideal scenario would involve universal acceptance of diversity without obstacles, the reality is that not everyone shares this objective. Consequently, it becomes crucial for the formal organisational structure to actively prevent diversity marginalisation.

7.3. CHALLENGES IN STRENGTHENING COLLABORATION

When considering diversity, it is crucial to recognise the numerous advantages it offers to a team, including heightened creativity and innovation, enhanced decision-making capabilities, improved problem-solving skills, and increased adaptability (Liang et al., 2010; Silva et al., 2020). However, it is essential to acknowledge that if not effectively

managed, the negative repercussions of diversity can outweigh its positive effects, underscoring the necessity of strengthening collaboration within the team to mitigate these challenges. A few different methods are recommended similar to what has been found in existing literature, which focuses on reforming onboarding practices, embracing diversity and inclusivity, encouraging interdisciplinary collaboration, and addressing cultural and language barriers and considerations while building the formal organisational structure (Canestrino et al., 2022; Taka et al., 2022).

While the solutions are rather straightforward theoretically, in reality, they are rarely implemented to a satisfactory level. Implementing ways to strengthen collaboration in organisations requires a concerted effort from all stakeholders involved. It may require a shift in organisational culture, additional resources, and strong leadership support to be successful. (Gerlach & Gockel, 2022; Taka et al., 2022). It's important to recognise that change takes time and perseverance, and organisations need to be prepared for setbacks and learn from them in order to make sustainable progress. There is no one-size-fits-all solution, and different teams require different approaches. It's important to be flexible, learn from experiences, and adapt strategies to suit the specific needs and dynamics of the team.

7.4. FEASIBILITY OF SOCIAL NETWORK ANALYSIS

This study demonstrates the practicality of employing Social Network Analysis (SNA) to assess the impact of diversity initiatives within organisations at a theoretical level. In practice, implementing such a tool is often easier than one might expect, mainly due to the organisation's ability to gather continuous and more precise data. Unlike many existing techniques used to measure the effects of diversity and inclusion efforts, which tend to be qualitative and lack comparability, SNA circumvents these challenges. Consequently, companies can readily adopt SNA, to better implement the strengthening measures, and develop a 'tailored solution' that best fits the company. However, this research also shows the pitfalls of using Cross's approach of frequency, responsiveness, effectiveness and energy, where bias in the participants directly leads to noise in the data with high effectiveness and energy scores, making it hard to use them for network analysis. Therefore, the choice of relationship questions based on the amount of trust the participants have in the surveyor is of the utmost importance to get reliable data.

7.5. SCIENTIFIC CONTRIBUTION

This research makes significant scientific contributions in two key areas: diversity and social network analysis. Firstly, it addresses a novel aspect by investigating the impact of diversity on the social structure of project teams. This subject has not been extensively explored in this manner previously. Previous research usually focused on studying multiple small teams (~5 people) with overall network characteristics like centralisation and density, without looking at the individual characteristics (power, influence and communication) (Mayo & Pastor, 2011; Tröster et al., 2014) Additionally, this research goes beyond examining diversity alone and includes a comparison between diversity and formal

organisational structure. By considering the interplay between diversity and the formal organisational context, this study provides valuable insights into the complex dynamics that shape project teams, ultimately contributing to a more comprehensive understanding of team collaboration. By examining clustering and homophily effects in construction project teams, this research fills a gap in the existing literature, that have only looked at clustering and homophily at gender diversity levels in large communities (Villesèche et al., 2020). Cross et al.'s (2004) relationship questions form the foundation for analysis in this research. This study acknowledges the potential biases associated with this method, which could occasionally lead to inaccurate results. These scientific contributions enhance our understanding of diversity's influence on project team dynamics and shed light on the previously unexplored effects of clustering and homophily in this context.

7.6. LIMITATIONS

This section discusses the limitations of this research. The limitation are as follows: -

- **Team Attributes: -** The teams studied for this research varied in size, and only two teams were studied, making it hard to generalise the results. The uniqueness of the teams could contribute to network characteristics, which can act as noise. The size of the teams is also relatively small to observe major differences. Therefore, the differences observed may be more significant in larger teams or organisations.
- **Data Collection: -** Collecting reliable and comprehensive data on diversity and social network structures is challenging. The accuracy of self-reported diversity measures and potential biases in network data collected (e.g. unusually high effectiveness and energy scores) will introduce measurement errors. Incomplete network data in the form of non-responding actors in a group-bounded approach can also bring potential bias if important actors are missed.
- **Causality and Directionality: -** SNA can provide insights into the structure of social relationships, but establishing causal relationships between diversity and network patterns is complex. Determining whether diversity influences network structures or vice versa requires careful consideration.
- **Network Evolution: -** Diversity and social networks are dynamic, evolving phenomena. A snapshot analysis may not capture the changes in network structures over time. Longitudinal studies or event-based analysis could provide a more nuanced understanding of these dynamics. Such studies, can also cancel out the effects of uniqueness that each team has, and makes comparisons more accurate.
- **Subjectivity and Perceptions: -** Perceptions and subjective interpretations of diversity and network relationships can influence the outcomes. Individuals' biases or social desirability effects in self-reporting or surveys can introduce potential distortions in the data. A lack of trust can also magnify this effect, as the research is done outside the organisation.

8

Conclusion and Recommendations

The concluding chapter of this thesis provides a comprehensive overview of the scientific and technical implications derived from the research findings. Before addressing the main research question, it is important to summarise the research methodology used and concisely answer the sub-questions, laying the foundation for addressing the main research question. Practical recommendations and suggestions for future research will also be presented. These recommendations aim to provide valuable insights for practitioners in managing diversity within project teams and offer directions for further investigation.

8.1. Research Goals and Conclusion

This research adopts an exploratory approach to examine the effects of diversity on the social structure of project teams. Social network analysis, a quantitative tool, interprets the data and addresses the main research question. Two surveys are conducted to collect relational data. The relationship data is visualised and analysed using metrics such as network centralities, density, centralisation, clustering, and homophily. Results are validated through expert interviews, culminating in the compilation of findings and recommendations for mitigating the adverse effects of diversity while harnessing its benefits in the construction industry.

Sub-Question 1: - What is diversity in teams from a theoretical perspective?
Diversity within project teams encompasses a range of characteristics that distinguish team members from one another. These characteristics can be broadly classified into two categories. The first category encompasses personal traits and attributes such as age, gender, physical attributes, language, nationality, race, religion, family structure, sexual orientation, and political views. These personal characteristics are connected to

an individual's personality, shape their perception of issues and circumstances, and influence their interpersonal relationships. The second category comprises characteristics and conditions closely tied to the job, including education and knowledge, functional background, experience, organisational tenure, and team tenure. These job-related factors contribute to an individual's expertise, professional background, and duration of engagement within the organisation and the project team.

Sub-Question 2: - How are the diversity dimensions manifested within the project teams?
Team 1 had the largest proportion of participants aged between 30 and 40, while in Team 2, the largest group fell between the ages of 40 and 50. Men constituted the majority of respondents in both Team 1 and Team 2. In terms of educational qualifications, Team 1 had a higher number of participants with bachelor's degrees, whereas Team 2 had a greater representation of individuals with master's degrees. Team 1 displayed a diverse composition with members from various nationalities, whereas Team 2 consisted entirely of Dutch members. The data also revealed that a majority of respondents in Team 1 had been working within their team for more than six years, while Team 2 was in its developmental stage, with a mix of members who had been with the team for one to five years. In regard to functional backgrounds, Team 1 was less diverse than Team 2, although culturally, Team 1 exhibited greater diversity compared to Team 2.

Sub-Question 3: - How does diversity affect the distribution of power, influence, communication and clustering within the project team?
Diversity negatively impact the distribution of power, influence, and communication within project teams, manifesting in three distinct ways. Firstly, age and experience were found to significantly influence the closeness between team members, with the highest levels of closeness observed in individuals in their middle ages (30-50 years old) and with moderate levels of experience (10-30 years). Secondly, education and functional background emerged as important characteristics for power, influence and communication in consultancy-based teams or teams involving experts. However, this trend was less pronounced in project teams. Lastly, nationality and gender were identified as factors contributing to similarity-based connections and clustering within project teams. Notably, nationality had a stronger influence on similarity-based connections compared to gender. These findings underscore the complex interplay between diversity dimensions and their impact on the social structure of a project team.

Sub-Question 4: - How can collaboration within the project team be strengthened?
While diversity can have adverse effects on the social structure of a project team, it also brings numerous positive benefits to a project team. By implementing the following strategies, the detrimental impacts of diversity can be minimised, allowing the team to fully leverage the positive effects it offers. Effective onboarding processes should prioritise trust-building, team bonding, and the integration of new members to strengthen collaboration within project teams. Embracing diversity and inclusivity is crucial, fostering collaboration among team members from different backgrounds and ensuring equal access to information. Encouraging interdisciplinary collaboration enhances problem-solving and the quality of expert solutions. Addressing cultural and language barriers

through awareness and support, such as language training, promotes improved team communication. An inclusive formal organisational structure should also be considered, ensuring equitable distribution of power and influence.

Main Research Question: - What are the effects of diversity on the social structure of a project team?

The effects of diversity on the social structure of a project team are multifaceted and have been explored through several sub-research questions. Firstly, diversity encompasses a range of personal traits and job-related characteristics, highlighting the complexity of factors that differentiate team members. This includes age, gender, language/ nationality, experience, education, and functional background. Location, organisation, and department are additional parameters that are further added to explain some of the characteristics of the project team. Incorporating these dimensions and the additional parameters provides a comprehensive understanding of the diverse factors influencing team dynamics.

Diversity has adverse effects on the social structure of a project team. Age and experience affected the influence that team members had within the team, while education affected the power, influence and communication patterns within the team. Nationality, gender and functional background increased the tendency of clustering and the formation of similarity-based connections.

Effective onboarding processes prioritising trust-building, team bonding, and integrating new members are essential to strengthen collaboration within diverse project teams. Embracing diversity and inclusivity fosters collaboration among team members from different backgrounds, ensuring equal access to information and preventing the isolation of specific sub-groups. Encouraging interdisciplinary collaboration enhances problem-solving and the quality of expert solutions. Addressing cultural and language barriers through awareness, support, and resources, such as language training, improves team communication. Moreover, creating an inclusive formal organisational structure that promotes equitable distribution of power and influence is crucial.

8.2. RECOMMENDATIONS

The findings of this research clearly demonstrate the presence of diversity within every project team, and it is evident that effective management of diversity can significantly enhance collaboration within the team. However, despite this understanding, it is apparent from discussions with field experts and observations from the collected data that diversity is still not being managed to its full potential. It is crucial to acknowledge that investing time and effort in mitigating the negative effects of diversity can yield substantial benefits that outweigh the associated costs. Therefore, this section aims to provide practical recommendations based on the research findings and proposes possibilities for future research to explore this important subject further.

8.2.1. RECOMMENDATIONS FOR PRACTICE

Sub-question 4 forms the basis of the recommendations for the industry. The following are some of the important recommendations for the industry: -

- **Reforming the onboarding process: -** Implementing effective onboarding programs that focus on trust-building, team bonding, and integrating new members is crucial. Provide support and resources to facilitate the assimilation of diverse team members and promote a sense of belonging. Adopting a proactive approach to onboarding, as opposed to the current reactive industry standards, is crucial.
- **Foster a culture of inclusion and collaboration: -**Embrace diversity as a valuable asset and create an inclusive environment that values different perspectives and promotes equal access to information. Encourage open communication, active listening, and respectful dialogue among team members. The experts emphasised the importance of achieving diversity and cultivating inclusivity. This understanding highlights the industry's evolving perspective, acknowledging the significance of not just having a diverse workforce but creating an inclusive environment where every individual feels valued, respected, and empowered, and this is a step in the right direction.
- **Encourage cross-functional collaboration: -** Recognise the benefits of interdisciplinary collaboration by encouraging experts from different functional backgrounds to work together. This collaboration can enrich problem-solving approaches, foster innovation, and enhance the overall quality of project outcomes.
- **Address cultural and language barriers: -** Raise awareness about the potential impact of cultural disparities and language barriers on team communication. Provide language training programs and resources to bridge language gaps and promote effective communication. Foster a culture of empathy, understanding, and mutual respect among team members.
- **Provide diversity training and education: -** Offer training programs and workshops to enhance team members' diversity awareness, sensitivity, and cultural competence. Encourage continuous learning and professional development opportunities to foster a deeper understanding and appreciation of diversity.

8.2.2. RECOMMENDATIONS FOR FUTURE RESEARCH

The following are some of the recommendations for future research: -

- **Leadership and diversity:-** Exploring the role of leadership in shaping the social structure of diverse project teams. Leadership plays a crucial role in setting the tone for team dynamics and fostering inclusivity within diverse teams. Future research can investigate various aspects of leadership in relation to diversity, such as leadership styles, leadership behaviours and leadership development. By integrating social network analysis with the study of leadership and diversity, researchers can gain a deeper understanding of how leadership practices and network structures shape the social dynamics within diverse project teams. This can

inform the development of evidence-based strategies and interventions to foster inclusive leadership, enhance communication, and promote positive interactions within diverse teams.

- **Diversity and conflicts using SNA: -** The examination of diversity and its impact on team conflict presents a significant aspect that poses challenges for measurement using social network analysis (SNA), which typically relies on static snapshots of team interactions at specific time points. However, by incorporating conflict-related relationship questions into longitudinal SNA surveys, a promising avenue emerges for a more comprehensive understanding of how conflict influences collaboration within project teams. This combined approach allows for the exploration of the intricate dynamics between diversity, conflict, and collaborative outcomes over time. By tracking the evolution of relationships and integrating conflict-related metrics, researchers can enhance their insights into the complex interplay of these factors, facilitating a deeper understanding of the relationship between diversity, conflict resolution strategies, and the overall effectiveness of project team collaboration.

- **Longitudinal studies: -**Conducting longitudinal studies using SNA to observe how diversity within project teams evolves over time will lead to more accurate results than the current methodology followed in this research. This would involve tracking the changes in network structures and relationships among team members as diversity factors shift and adapt. This method would also reduce many of this research's limitations, as longitudinal studies can easily account for the uniqueness of each team. But, this requires considerable time and effort and the researcher to be embedded and trusted within the organisation.

- **Industry tools: -** Based on the findings of this research, there is potential for the miniaturisation and development of the SNA tool to be more easily deployable in project teams. This enhanced tool could effectively capture the evolution of teams over time and correlate it with team performance, providing organisations with valuable insights into team functioning. Instead of relying solely on surveys, alternative data collection methods, such as electronic tools incorporating proximity sensors, or tracking organisational email interactions, could be explored for more efficient and comprehensive data gathering. For example, wearable devices like wristbands with proximity sensors or automated email tracking systems could be utilised to capture real-time data on team interactions and relationships. Such advancements would enhance the usability and practicality of SNA in understanding team dynamics and improving team performance.

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A

PRELIMINARY SURVEY SAMPLE

Preliminary Survey
Social Network Analysis – Organisation Name

1. **Please provide some basic information about yourself**

Name: -
Location: -
Department: -

2. **Please provide some more detailed information about yourself for this study**

Age: -
Gender: -
Nationality
Organisational Tenure[1] : -
Team Tenure[2]: -
Educational Degree[3]: -
Educational Specialisation[4]: -

3. **Team Members**

Please add the names of up to 3 people that you work with on a regular basis that are **NOT** included in the list given below.

LINK TO LIST
Name 1: -
Name 2: -
Name 3: -

[1] Organisational Tenure: - Please mention how long you have been working as an employee of Organisation
[2] Team Tenure: - Please mention how long you have been working with the team you are currently a part of
[3] Educational Degree: - Please choose between Secondary School, Bachelors, Masters, PhD
[4] Please mention the specialisation in which you have achieved your highest degree in

B

Relationship Characteristics

Questions to uncover important relationship characteristics	
Relationships That Reveal Collaboration in a Network: - The communication and the information relationship can be strong indicators of current or recent collaboration within a network. The problem-solving and innovation relationships tend to be more selective and require a higher level of trust between people. Assessing some combination of these relationships is often important because they characterise how work is getting done in knowledge-intensive settings.	
Communication	How often do you talk with the following people regarding topic x? How much do you typically communicate with each person relative to others in the group?
Information	How frequently have you acquired information necessary to do your work from this person in the past three months? Please indicate the extent to which each person provides you with information you use to accomplish your work. From whom do you typically seek work-related information? To whom do you typically give work-related information?
Problem-solving	Whom do you typically turn to for help in thinking through a new or challenging problem at work?

	How effective is each person in helping you to think through new or challenging problems at work?
Innovation	Whom are you likely to turn to in order to discuss a new or innovative idea?
Relationships That Reveal the Information-Sharing Potential of a Network: - Assessing these relationships, either individually or by combining them, can provide actionable ways of improving a network's potential to react to new opportunities and threats.	
Knowledge awareness	I understand this person's knowledge and skills. This does not necessarily mean that I have these skills or am knowledgeable in these domains but that I understand what skills this person has and the domains he or she is knowledgeable in.
Access	When I need information or advice, this person is generally accessible to me within a sufficient amount of time to help me solve my problem.
Engagement	If I ask this person for help, I can feel confident that he or she will actively engage in problem-solving with me.
Safety	Please indicate the extent to which you feel personally comfortable asking this person for information or advice on work-related topics.
Relationships That Reveal Rigidity in a Network: - These relationships highlight constraints in a network, such as bottlenecks, due to over-dependence on a key decision maker or clustering around powerful personalities.	
Decision making	Please indicate whom you turn to for input prior to making an important decision
Communicate more	I would be more effective in my work if I were able to communicate more with this person.
Task flow	Please indicate the extent to which the people listed below provide you with the inputs necessary to do your job. Please indicate the extent to which you distribute outputs from your work to the people listed below.

Power or influence	Please indicate the extent to which you consider each person listed below to be influential at [the name of the organisation]- that is, people who seem to have pull, weight, or clout in this company.
Relationships That Reveal Well-Being and Supportiveness in a Network: - These dimensions of relationships can be used in various combinations to assess the general atmosphere and supportiveness within a group.	
Liking	Please indicate how much you like each person.
Friendship	Please indicate the people you consider to be personal friends, that is, those people you see most frequently for informal activities such as going out to lunch, dinner, drinks, visiting one another's homes, and so on.
Career support	Please indicate who has contributed to your professional growth and development. Include people who have taken an active interest in and helped to advance your career.
Personal support	Please indicate people you turn to for personal support when your work is going poorly, a project is failing, or you are frustrated with certain decisions.
Energy	When you interact with this person, how does it affect your energy level?
Trust	Please indicate the people in this group you would trust to keep your best interests in mind.

C

SNA Main Survey

Table C.1: SNA Matrix

Name	Frequency	Responsiveness	Effectiveness	Energy
1				
2				
3				
4				
5				

C.1. Survey Questions

1. Frequency: - Please indicate the frequency with which you typically turn to this person for work-related issues.

0. I do not know this person
1. Never
2. Seldom
3. Sometimes
4. Often
5. Always

2. Responsiveness: - Please indicate the responsiveness of each individual in replying to your work-related requests.

0. I do not know this person
1. Often fails to respond
2. Usually responds, but slowly
3. Generally responds within a week
4. Typically responds within 24 hours
5. Always responds within the same day
6. N/A

3. Effectiveness: - This person is effective in helping me solve relevant work related problems?

0. I do not know this person
1. Strongly Disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly Agree
6. N/A

4. Energy: - I feel energised when I interact with this person?

0. I do not know this person
1. Strongly Disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly Agree
6. N/A

D

Basic Network Characteristics Team 1 & Team 2

Table D.1: Network Measures Team 1

	Closeness	**Betweenness**	**PageRank**	**Clustering**
1	1	0.065542	0.036352	0.414141
2	0.5625	0.003138	0.023083	0.692105
3	0.542169	7.06E-05	0.005876	0.952381
4	0.762712	0.027231	0.032988	0.493651
5	0.584416	0.007558	0.027893	0.61
6	1	0.049695	0.03159	0.416667
7	0.737705	0.022385	0.027231	0.532977
8	0.6	0.017724	0.036066	0.529032
9	0.56962	0.007522	0.023697	0.62619
10	0.616438	0.004109	0.016304	0.657895
11	0.849057	0.0379	0.032058	0.47031
12	0.625	0.010821	0.021594	0.57

13	0.584416	0.001756	0.016836	0.814103
14	0.681818	0.012778	0.024697	0.566667
15	0.681818	0.008841	0.020517	0.576355
16	0.5625	0.001447	0.012808	0.809524
17	0.642857	0.00981	0.028202	0.603989
18	0.54878	0.00374	0.021572	0.702206
19	0.584416	0.002763	0.018009	0.745614
20	0.592105	0.004786	0.024976	0.679842
21	0.56962	0.009148	0.036306	0.59127
22	0.6	0.003687	0.019285	0.728947
23	0.483871	0.001501	0.020462	0.728947
24	0.681818	0.01203	0.020985	0.548433
25	0.625	0.010047	0.022882	0.606884
26	0.576923	0.003594	0.017768	0.684211
27	0.56962	0.001053	0.011153	0.845455
28	0.6	0.001652	0.014686	0.82381
29	0.652174	0.006204	0.019585	0.604743
30	0.692308	0.010107	0.017278	0.593846
31	0.616438	0.007775	0.021884	0.715686
32	1	0.092905	0.047592	0.411111
33	0.661765	0.004191	0.011695	0.642857
34	0.584416	0.001805	0.016484	0.666667
35	0.54878	7.73E-04	0.013255	0.833333
36	0.5625	8.92E-04	0.009945	0.822222
37	0.652174	0.011711	0.021203	0.690476
38	1	0.040134	0.023014	0.417172
39	0.625	0.004204	0.015804	0.728947
40	0.6	0.004684	0.016856	0.714286
41	0.75	0.027996	0.027233	0.533144

42	0.592105	0.002618	0.014432	0.758242
43	0.737705	0.01182	0.020125	0.517647
44	0.473684	9.04E-04	0.020643	0.725
45	0.865385	0.033494	0.030588	0.473684
46	0.5	0	0.006508	0.844444

Table D.2: Network Measures Team 2

	Closeness	**Betweenness**	**PageRank**	**Clustering**
1	0.666667	0.002712	0.02565	0.884615
2	0.631579	0.001268	0.022896	0.909091
3	1	0.044481	0.056455	0.599638
4	0.615385	1.42E-03	0.026654	0.910256
5	0.727273	0.014319	0.044098	0.738095
6	1	0.051543	0.069263	0.594203
7	0.923077	0.031207	0.054472	0.655844
8	0.571429	2.01E-04	0.019641	0.97619
9	0.96	0.050723	0.065959	0.614625
10	0.96	0.043383	0.068426	0.626482
11	0.857143	0.031236	0.065838	0.658009
12	0.666667	0.003253	0.028589	0.878205
13	0.615385	0.003511	0.022401	0.863636
14	1	0.059725	0.071026	0.592391
15	0.6	8.66E-04	0.022621	0.928571
16	0.705882	0.006247	0.037433	0.824176
17	0.685714	0.005019	0.0369	0.833333
18	0.615385	6.18E-04	0.019087	0.944444
19	0.648649	0.001235	0.030518	0.927273
20	0.774194	0.011404	0.028492	0.75

21	0.631579	6.18E-04	0.031276	0.955556
22	0.705882	0.006177	0.039888	0.818681
23	0.774194	0.020197	0.041685	0.699346
24	0.727273	0.009508	0.037414	0.768382
25	0.705882	0.006737	0.033321	0.8

E

Expert Selection and Interview Structure

E.1. Selection of Experts

Experts were chosen based on their extensive experience and knowledge in construction project management or human resource management, particularly in team dynamics and diversity. The selection process aimed to include professionals who possess a deep understanding of diversity and social network analysis and can provide insights into the impacts of diversity on construction project teams.

To identify suitable experts, three criteria were established. The criteria considered during the selection process are expertise, experience and accessibility. The experts had to possess significant expertise in construction project management or human resource management, with a focus on team dynamics and diversity-related issues. This gives them a comprehensive understanding of the complexities and challenges of managing diverse project teams. Preference was given to experts with extensive practical experience in the construction industry, specifically in leading or managing construction projects and teams. Their experience would provide valuable perspectives on the real-world implications of diversity in project settings. Experts who were accessible and willing to participate in the interview process were prioritised.

Two experts were selected to participate in the interview process. These people were selected to offer in-depth insights into how diversity affects the social structure of project teams in the construction industry. Their participation provided insights that enriched the results of the social network analysis conducted in this study.

E.2. INTERVIEW STRUCTURE

The expert interviews were conducted through Microsoft Teams using the platform's integrated transcription and recording tools. Approximately one hour was spent on each interview session. Before the interview, the experts received a more comprehensive description of the research as a preamble based on the insights gained from this initial interview. In this way, the participants were up to speed on the study's objectives and content, enabling them to provide more detailed and focused responses.

Data collection and analysis were carried out manually due to the limited number of interviewees (two). To extract relevant information and insights, the interviews were transcribed and reviewed. This manual approach was chosen due to the manageable size of the dataset, allowing for a comprehensive analysis of the expert opinions and perspectives. The qualitative data obtained from the interviews were then analysed thematically, identifying common themes, patterns, and significant variations in the experts' responses. This analysis aimed to extract meaningful findings contributing to the research objectives and providing valuable insights.