# Virtual Teams: The Impact of Varying Levels of Virtuality On Project Team Performance

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## Abstract

Although virtual teams have existed for over two decades, in recent years the Covid-19 pandemic led to a wider adoption and transition to virtual teamwork by most organizations. Virtuality is operationalized as the proportion of work done remotely or virtually on a project. This research studies the moderating effects of virtuality in project teams on communication frequency, leadership effectiveness, and project team performance. Using the theoretical frameworks of Adaptive Structuration Theory and Transformational Leadership Theory, a survey was carried out that informed this cross-sectional study. Respondents were project team members and managers who were involved in AEC (Architecture, Engineering and Construction) and Finance/IT projects before and during the Covid-19 pandemic.

This study showed that the inverted-u relationship between communication frequency and project performance was preserved in only low virtuality teams, while the shape of the curve was different for high virtuality teams. AEC project performance was also found to be more sensitive to communication frequency, as these projects exhibited inverted-u relationship with performance compared to Finance/IT projects which was more linear. Regardless of the levels of virtuality in project teams, transformational leadership leads to significantly better performance in both types of projects. This study contributes to the body of literature in project management and information systems by measuring one of several dimensions of virtuality in the proposed model and provides insights for project managers in industry to better lead their virtual project teams.



**Keywords:** virtuality, project team performance, leadership effectiveness, communication frequency, Adaptive Structuration Theory, Transformational Leadership Theory

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## 1. Introduction

Although virtual teams have existed for over two decades, in recent years the Covid-19 pandemic led to a wider adoption and transition to virtual teamwork by most organizations (Venkatesh, 2020). Pre-Covid-19, virtual teams were primarily assembled as a matter of choice and were adopted based on the organization's efforts to gather and collaborate with geographically dispersed talent (Allen et al., 2015). However, with social distancing growing more prevalent in organizations, the extent of physical collaboration and face-to-face communication among team members has been limited (Herath & Herath, 2020). Project teams across organizations have now been forced to rely more on virtual collaboration to achieve their project goals and objectives while working to maintain an acceptable level of performance both on their projects and as a team (Eurofound, 2021).

As a result, virtual teamwork adoption has since rapidly transitioned from being optional to a matter of organizational survival (Richter, 2020). For instance, global companies such as LM Ericsson, Barclays, Unilever, Facebook, Twitter, PwC and Mckinsey & Company had requested that their employees continue to work virtually, showing that the virtual teamwork – although still difficult to forecast its long-term implication – is here to stay (Boland, De Smet, Palter, & Sanghvi, 2020). Virtual teams have become vital to maintaining our increasingly globalized economy and organizational structure (Morrison-Smith & Ruiz, 2020)

With this widespread adoption, it is safe to expect that gaps in performance are being experienced in organizations who have made the shift from typically traditional

means of collaboration and communication to a more virtual means (Velicia-Martin et al., 2021). While some leaders already have experience in leading virtual teams and meetings and are adept at using virtual collaboration platforms, other leaders and team members struggle with these tools and end up having collaboration challenges due to their technological inadequacies. The performance gaps could be partly traced —among other factors— to the sudden transitioning with limited technical competencies and training necessary for virtual collaboration. Challenges such as poor communication resulting from the limited physical contact, distractions arising from working remotely and in a more comfortable environment, slower response times in teams located in different time zones (Cummings et al., 2009) as well as a general lack of office culture in remote teams are therefore bound to play a part in the performance gaps within such teams.

Researchers have also found that other factors, such as trust affect virtual team collaboration. For instance, DeRosa, Hantula, Kock, & D'Arcy (2004) linked higher levels of trust within a team to better team satisfaction and morale which indirectly influences team performance. Usually, higher trust between virtual team members provides benefit of doubt to team members when erroneous or 'triggering' information that can be misconstrued is shared using technology (Gaan, 2012). In the same vein, the social context that provides an avenue to develop trust among team members is lost in virtual collaboration, hindering the process of fostering trust.

To date, few studies have tried to explore how the transition to virtual project teamwork, and adoption of the technological tools have impacted project performance as a direct consequence of the current pandemic. Over the years, the benefits and

challenges of virtual teams in organizations have received a lot of industry and academic focus, and with this bourgeoning work culture of social distancing and remote work, more studies are still being done in this field. However, very little research emphasizes how the proportion of time spent on virtual collaboration - also referred to as 'virtuality'- adopted by a project team influences the overall performance of the project team (Gibson & Gibbs 2006). In addition, studies on virtual teams have mostly been conducted from an organizational perspective, however, much fewer research has been done in understanding virtual teamwork through the lens of project management and how project performance is being affected by the increasing adoption of virtual teamwork.

Various dimensions of virtual teams have been studied. For instance, due to the nature of virtual teams, for it to work effectively and efficiently, it is important that the communication process put in place is highly effective. This is obvious since virtual collaboration requires the use of technology for communication within the team instead of being face-to-face. This applies to both face-to-face and virtual teams, as communication is a crucial element of both virtual and co-located teams. With the need for effective communication in virtual teams, such effectiveness is impossible without the use of information and communication technologies (ICT) tools (Montoya et al. 2009).

Furthermore, putting project teams into perspective, the successful accomplishment of project tasks also hinges on effective communication within the team as well as the fostering of strong working relationships (Huemann, 2010). With the use of virtual collaboration tools because of this new work culture, the

communication style within the project team has become significantly different from what it used to be. These differences in communication style have made the challenges in virtual teams more obvious. Teams are now communicating more frequently than they used to with the use of technological tools, and are adopting new virtual collaboration platforms, just to get their projects done, leading to information overload (Marks et al., 2000).

Challenges such as differences in time-zones, distractions from an out-of-office environment (e.g working from home) (Miloslavic et al. 2015) to name a few, also pose major threats to the performance of the project team due to virtual collaboration (Gibson & Cohen, 2003). The project manager, who is the leader of the project team now faces an entirely new challenge in leadership with greater difficulties in monitoring team members and maintaining accountability, physical collaboration as well as timely resolution of project and personnel-related challenges. The virtual teamwork then puts the project manager in new frontiers of leadership challenges which, if unequipped to tackle effectively, could put both the project manager and the team at risk of project failure.

Another fallout of the current Covid pandemic is the lack of media richness being faced by project teams during virtual collaboration; indeed, this has been one of the biggest challenges for virtual teams (Garro-Abarca et al., 2021). This is especially due to social distancing policies across the globe, and as such continues to pose a major communication challenge for virtual teams. With this lack of richness in communication – which essentially refers to the level of depth and interactivity experienced during communication – team members are restricted from interacting face-to-face, taking

away one of the crucial aspects of communication. When team members are unable to communicate physically, share ideas and collaborate physically, this puts a strain on how quickly and efficiently the project tasks are performed. Consequently, with the performance of a project generally being measured based on the team's ability to perform the project activities within the constraints of scope, time, budget (or cost) and quality, the introduction of virtual collaboration – while having significant benefits –tend to affect how well the project team performs (Ludden & Lewith, 2014).

With these in mind, a research need has therefore been identified to explore the ways in which projects executed during the pandemic have been impacted by the way the teams now collaborate and communicate virtually with the use of virtual tools, and how these have influenced the project team performance (El-Tayeh, Gill & Freeman, 2008; Idrus, Husin & Sodangi, 2011; Gordon & Curlee, 2011). It is important to again point out that previous studies on virtual teams have focused on organizational team performance and outputs (e.g. Krasnikov & Jayachandran, 2008) while others highlighted specific aspects of team performance like decision quality, time frame of decision-making and quality (Sosik & Jung, 2002). Nader et al. (2009) for instance, pointed out the need to identify and study different performance criteria and activities for enhancing virtual project team performance while Almahmoud, Doloi and Panuwatwanich (2012) studied the relationship between project performance and delivery with the use of the project's key performance indicators.

This study instead, will address how virtuality—which we define as the proportion of the time spent on a project that team members work virtually or remotely—influences the relationship between leadership effectiveness and project performance,

as well as the relationship between communication frequency and performance. *(See Appendix A for definition of terms).*

### 1.1 Background to the Study

According to Kirkman et al., (2002), the start of virtual teams can be traced to the 1990s when some multinational corporations in the US needed to integrate their practices with their affiliations in other countries and thus developed the concept of virtual teams. Since then, there has been a rapid proliferation of organizations' adoption and use of virtual teams to organize and combine efforts and achieve common goals.

Information Systems researchers have since studied the framework and features of virtual teams across various disciplines. The word 'virtual' as is used in virtual teams implies activities performed by cyber-enabled communication means (Hertel et al., 2005). A virtual or remote team has been defined as "a team made up of people who are not co-located and/or have different working hours and/or work across multiple teams simultaneously" (Pitagorsky, 2006). Virtual teams or remote teams in other words are typically those teams who communicate and collaborate electronically, typically due to geographical dispersion with the use of technology. These team members are usually located in various geographical areas and one of the features of such a team is that they communicate using virtual tools (Gibson & Cohen, 2003). These virtual teams have been receiving much attention in research literature as they have become more common in modern organizations, even in teams that are not geographically dispersed.

As a matter of fact, in 2016, a survey of 1372 respondents from different organizations across 80 countries revealed that 85% of them worked on virtual or remote teams (RW3 CultureWizard, 2016). This virtual collaboration typically occurs when face to-face meetings are impossible or expensive to conduct with most of the members in different geographical locations and is usually more useful in inter-organizational projects when tasks require combined efforts of team members from different organizations who cannot otherwise be collocated (Ahola, 2018). Many of these teams have even adopted social media on their mobile phones as ad hoc collaboration tools (Anders, 2016).

A more recent study of 2700 virtual team members from 106 countries by CultureWizard (2020) revealed that while only 34% of team members rate their virtual team leaders as effective, 23% of virtual team leaders rate themselves as effective. This same study also revealed that 89% of respondents considered communication as critical to virtual collaboration. As regarding how the respondents assessed virtual collaboration, 94% of team members want to continue working virtually at least half of the time and 52% actually use video conferencing tools for half of their team meetings.

Gradually, as recent technological advancements have enhanced long distance and virtual communication, more teams and organizations have begun to embrace virtual teams (Leonard, 2011). These technological tools, or communication tools that are used to share information and collaborate have become a key feature of virtual teamwork and are what makes virtual teams work. They are the bedrock on which virtual teams are built and they significantly influence how organizations adopt and benefit from virtual collaboration. With these tools being used to communicate more

effectively, several studies have since identified team communication as a major factor affecting performance in virtual teams (Marlow et al., 2017).

## 1.2 Identification of Problem

In any project, performance is a crucial indicator of project success as it is the ability of the project team to work optimally and achieve the highest level of effectiveness over a long period of time. An indicator of high performance therefore implies delivering and completing the project within the triple constraints of scope, time and cost while maintaining a high level of quality (PMI, 2008). This applies not only to project teams but also to functional teams and is measured using metrics that define the goals and objectives of the organization or project.

According to Schweitzer & Duxbury (2010), the use of virtual tools has been found to cause communication delays which ends up leading to a dip in project performance. For instance, delay in receiving important information by a member of the project team could lead to such team members executing certain parts of the task without the required information, leading to errors, omissions and rework for the team, and ultimately a drop in project performance.

In addition to performance being influenced by communication in a virtual team, the role of the project manager has also been greatly impacted by the adoption of virtual teamwork. This virtual work culture has automatically demanded more effective leadership from the project manager (Hossein, 2012) with the typical leadership style

for managing traditional (co-located) teams being increasingly inadequate for effectively leading and managing more complex virtual team structures.

Our argument in this paper, therefore, is that although there exist in literature relationships between communication, leadership and performance in virtual teams, virtuality—which we define as the proportion of the time spent on a project that team members work virtually or remotely—can either strengthen or weaken the relationship between them. For instance, in a team with predominant use of virtual teams, the more frequently the team members communicate virtually, there is a tendency for relevant information being shared to be mixed up with irrelevant information especially when there is too much information being shared. On the other hand, efficiency may be gained in some ways, including reduction of delays associated with paperwork changing hands, physical approval of documents and authorizations, commuting and traveling, leading to quicker execution of tasks and faster turnaround on deliverables.

### 1.3 Contribution of the Study

One significant contribution of this study is its' timeliness. Considering the rate at which many project teams have resorted to virtual collaboration more than usual because of the Covid-19 pandemic, there invariably exist inconsistencies in the performance levels of these project teams. These inconsistences could stem from how well the team uses the communication tools at its disposal, how frequently they adopt virtual collaboration during the project and how equipped the leader or project manager is in managing a virtual team. However, in this study, we expect that the

effects of communication frequency within project teams, and the effectiveness of the project leadership on the overall project performance will be significantly moderated by the level of virtuality being adopted by such teams.

Expanding on previous research efforts which have focused more on specific areas of virtual teams with very little work being done on virtual project teams from a project management perspective, we want to explore—given the critical importance of communication and leadership in a virtual project team team's overall performance—the role of varying levels of virtuality adopted by the teams and how project teams can benefit from it. This paper will more specifically identify and analyze the moderating role of virtuality on the relationships between communication frequency and leadership effectiveness on project team performance, as well as provide insight on how performance in project teams can be enhanced.

Finally, this study aims to contribute to the current understanding of virtual teams exclusively from a project management perspective by surveying a cross-section of both project managers and project team members in specific industries and assessing how their adoption of virtual project teamwork impacts the overall performance of their projects. This study will also add to existing Information Systems and Project Management bodies of research on virtual teams and project management in understanding the impact of such teams on project performance .

Specifically, we seek answers to the following research questions:

1. Is there a relationship between leadership effectiveness and project performance?

2. Is there a relationship between communication frequency and project performance?
3. Does virtuality moderate the relationship between leadership effectiveness and project performance?
4. Does virtuality moderate the relationship between communication frequency and project performance?

Thus, the overall goal of this study is to contribute to the body of research on virtual teams and project management to help practitioners execute and complete projects more successfully in a virtual environment. Two specific goals are related to the possible moderating influence of virtuality on the links between the two predictor variables (leadership effectiveness and communication frequency) and project team performance.

The rest of this study is structured as follows. An extensive review of the literature on virtual teams is provided, followed by a review of the term 'virtuality' as used in previous studies. Subsequently, the key constructs and the theoretical framework and model are defined, followed by the operationalization of the different constructs used in the study. Research hypotheses are then proposed based on theory found in literature. The hypotheses examine the relationships between leadership effectiveness and project performance, communication frequency and project performance, as well as the moderating role of virtuality on the individual relationships. In section four, the methodology, hypotheses testing, analysis and findings are discussed. In section five, the academic and managerial implications of the study are

also presented. The paper concludes by noting the limitations of the study and offering recommendations that may guide future studies of virtual teams.

# 2. Literature Review

## 2.1 Overview of Virtual Teams Literature

A team can be defined as ‘‘a collection of individuals who are independent in their tasks, who share responsibility for outcomes, who see themselves and are seen by others as an intact social entity embedded in one or more larger social systems, and who manage their relationship across organizational boundaries’’ (Cohen and Bailey, 1997). Parker (1994) also defines a team as a collection of interdependent individuals whose mutual aim is to achieve a goal or complete a task. The term “virtual team” is a derivative of teams in general, with the distinct difference being the geographical dispersion of the team members and the use of virtual collaboration tools (Gibson & Cohen, 2003).

Over the years, virtual teams have been researched through many lenses and using different research methods as can be seen in *Table 1* below. Aspects such as communication (Anderson et al., 2007), leadership types (Purvanova and Bono, 2009), formation of virtual teams (Lin et al., 2008; Munkvold and Zigurs, 2009), key success factors (Harvey et al.,2004), virtual teams in the construction industry (Rezgui, 2007; Vorakulpiput et al., 2010) in the high-tech industries (Monalisa et al., 2008), cultural diversity and impact of Information Technologies (Shachaf, 2008), impact of reward structure, media richness and gender (Bryant et al., 2009), trust (Haarrel and Daim,

2009), and team leadership factors (Kozlowski & Bell, 2003; Zaccaro, Rittman, & Marks, 2001) are few of the aspects that received considerable attention in the area of virtual teams.

*Table 1: Studies in Virtual Teams by Research Method and Topics*

| Methodology | Topic | References |
|---|---|---|
| **Case Study** | Communication | Han, Hiltz, Fjermestad, & Wang, (2011); Bjørn & Ngwenyama, (2009); Watson-Manheim & Belanger, (2002) Wu et al., (2017) |
| | Conflict | Martinez-Moreno, Zornova, González-Navarro, & Thompson, (2012) |
| | Culture; | Cheng, Chua, Morris, & Lee, (2012) Choi & Cho (2019) |
| | Leadership | Domschke, Bog, Uflacker, & Zeier, (2009); Monalisa, Daim, Mirani, Dash, Khamis, & Bhusari, (2008); Kerber & Buono, (2004) |
| | Project Management | Casey & Richardson, (2006) |
| | Technology | Scialdone, Li, Howison, Crowston, & Heckman, (2008) |
| | Traditional vs. Virtual teams | Powell, Galvin, & Piccoli, (2006) |
| **Experiment** | Communication | Aritz et al., (2018) Pantelli & Davison, (2005); Sarker, Ahuja, Sarker, & Kirkeby, (2011); Qureshi, Liu, & Vogel, (2006); Lowry, Roberts, Romano, Cheney, & Hightower, (2006); Anderson, McEwan, Bal, & Carletta, (2007); Rico & Cohen, (2005); Altschuller & Benbunan-Fich (2010) Bui et al., (2019) Charlier et al., (2016) Glikson & Erez (2020) |
| | Conflict | Furumo, (2009); Pazos, (2012); Culture (Staples & Zhao, (2006); Humes & Reilly, (2008); Paul & Ray, (2009); Gevers & Peeters, (2008); Mockaitis, Rose, & Zettinig, (2012) |
| | Dispersion | Rutkowski, Saunders, Vogel, & van Genuchten, (2007); Sarker & Sahay, (2002); Espinosa, Nan, & Carmel, (2007); Martins & Shalley, (2011); Massey, Montoya-Weiss, & Hung, (2003) |
| | Team Effectiveness | Edwards & Sridhar, (2003); Lin, Standing, & Liu, (2008); |
| | Traditional vs. Virtual teams | Stevenson & McGrath, (2004) |
| | Technology | Turel & Connelly, (2012) |
| **Field Study** | Culture | Hung & Nguyen, (2008) |
| | Knowledge Sharing | Espinosa, Kraut, Slaughter, Lerch, & Herbsleb, (2007) |
| | Team Challenges | Espinosa, DeLone, & Lee, (2006) |
| | Team Effectiveness | Orlikowski, (2002); Workman, (2007) |
| | Leadership | Goh & Wasko, (2012) |
| **Interviews (Qualitative)** | Best Practices | Staples & Webster, (2007); Team Challenges (Hughes, O'Brien, Randall, Rouncefield, & Tolmie, (2001); Kirkman, Rosen, Gibson, Tesluk, & McPherson, (2002); (Dube & Robey, (2008) |
| | Communication | Belanger & Watson-Manheim, (2006); Daim, Ha, Reutiman, Hughes, Pathak, Bynum, & Bhatla, (2012) Bhat et al, (2017) |

| | | |
|---|---|---|
| | Culture | Au & Marks, (2012); Matveev & Milter, (2004); Gregory, Prifling, & Beck, (2009); Begley & Boyd, (2003); Chang, Chuang, & Chao, (2011); Dekker, Rutte, & Van den Berg, (2008) |
| | Project Success | Verburg, Bosch-Sijtsema, & Vartiainen, (2013) |
| | Team Structure | Bal & Gundry, (1999); Gassman & von Zedtwitz, (2003); Birnholtz, Dixon, & Hancock, (2012); Dube & Pare, (2001); Dixon & Pantelli, (2010); Dube, Bourhis, & Jacob, (2006) |
| | Technology | Thomas & Bostrom, (2010) |
| **Survey (Quantitative)** | Communication | Timmerman & Scott, (2006); Majchrzak, Malhotra, & John, (2005); Glikson & Erez, (2013); Henderson, (2008); |
| | Dispersion | Mohammed & Nadkarni, (2011); Cummings, Espinosa, & Pickering, (2009); Curlee, (2008); Holahan, Mooney, & Finnerty Paul, (2011); Hoegl, Ernst, & Proserpio, 2007; Cummings & Hass, (2012); O'Leary & Cummings, (2002) |
| | Measuring Virtuality | Chudoba, Wynn, Lu, & Watson-Manheim, (2005); Schweitzer & Duxbury, (2010) |
| | Team Effectiveness and Performance | Maynard, Mathieu, Rapp, & Gilson, (2012; Hardin, Fuller, & Valacich, (2006); Algesheimer, Dholakia, & Gurau, (2011); Anantatmula & Thomas, (2010); Chinowsky & Rojas, (2003) |
| | Technology | Kock & Lynn, (2012) |
| **Combination of qualitative and quantitative** | Best Practice | Chen & Messner, (2010) |
| | Team Performance | Ahuja, (2010) |
| | Dispersion | McKinney & Whiteside, (2006); Cramton & Webber, (2005) |
| | Leadership | Lee–Kelley, (2006) |
| | Team Virtuality | Gibson & Gibbs, (2006) |

*Source: Ludden & Lewith, (2014)*

Furthermore, studies by Krasnikov and Jayachandran, (2008) focused on overall virtual project team performance as well as outputs and outcomes while Dube and Marnewick (2012) established that the building blocks of virtual teams are communication, leadership, trust and social needs. In addition to these, several researchers also studied the benefits of virtual teams in the global workplace and its usefulness in enhancing team performance across diverse industries (Gordon & Curlee 2011; Ludden & Ledwith 2014). Majchrzak et al. (2000) studied an interorganizational virtual team in its adaptation and use of collaborative technology in achieving success on an innovative product. They borrowed the adaptive structuration theory model by

DeSanctis and Poole (1994) and Leornard-Barton's (1988) adaptation misalignment model to understand how the virtual team used and modified technology adopted in their production process. These various studies have been drawn from several journals and publications *(Table 2)*, showing the cross-disciplinary nature of virtual teams.

*Table 2: List of Journals and Publications with Virtual Teams literature*

| | |
|---|---|
| Journal of Economic Behavior and Organization | Human Resource Management Review |
| Strategic Management Journal | MIS Quarterly |
| Computational and Mathematical Organization Theory | Journal of Information and Management |
| Journal of Management | The International Association of Applied Psychology |
| Information Systems Research | Decision Support Systems |
| International Journal of Project Management | International Journal of Information Management |
| Mediterranean Conference on Information Systems (MCIS) | Journal of Computer Mediated Communication |
| Journal of Business Research | Group & Organization Management |
| Information & Management | International Journal of Business & Management |
| Journal of Management | Information & Management |
| Organizational Dynamics | Journal of Management Information Systems |
| SN Applied Sciences | Organizational Behavior and Human Decision Processes |
| Computers in Human Behavior | Human Resource Management Review |

### 2.2 Defining a Project and Project Teams.

According to the PMI Project Management Body of Knowledge (PMBOK®) Guide, a project 'is a temporary endeavor undertaken to create a unique product, service or result' (PMI, 2008, p. 434). Prince2 also defines a project as "a temporary organization that is created for the purpose of delivering one or more business products according to an agreed Business Case." (OGC 2009:16)

The operative word in both definitions is 'temporary' meaning that any activity that has no defined end is not considered a project. Also, for an activity to be

considered a project, it must be unique and therefore, any repetitive or routine activity is not considered a project.

Today, many organizations create temporary project teams where elements such as employees and technologies are brought together to accomplish a specific project and then disbanded once the project is completed (Huemann, 2010; Thirty & Deguire, 2007). This therefore infers that employees in an organization can often participate in some form of project or the other at any point in time, and disband once the project is completed.

For this study, this paper therefore defines a project as "*A temporary and unique endeavor to achieve a specific result or outcome and typically includes a series of interrelated activities executed over a pre-determined period of time and within the constraints of scope, quality, cost and schedule*".

With this definition, a project team is therefore *a group of individuals with different roles within the project who perform or execute the project task under the leadership of a Project Manager or leader who ensures that the project objectives are met*. These project team members support the project manager who takes on the leadership role and who coordinates the individual and collective efforts of the team members to successfully accomplish the project task.

### 2.3 Defining a Virtual Project Team

Due to the temporary nature of projects, it is logical that teams can be assembled either remotely or virtually to accomplish and execute a project and then

disperse after the project objectives have been met. According to Pulan & Prokopi (2016), a virtual project team is typically one where at least one member of the project team works remotely with the team. For the sake of this study therefore, we describe virtual teams as a group of individuals who work together remotely and rely on communication technology in order to collaborate. Our definition of virtual project teams is therefore derivative of the preceding 'virtual teams' definition with the significant difference being that virtual project teams include geographically dispersed team members who typically work on specific projects, and consistent with the definition of a project, these teams tend to disband after the project objectives have been met. Virtual project teams are usually assembled to perform specific projects such as short-term work engagements and of necessity must be spread across both functional and organizational units while maintaining geographical dispersion (Kossler & Prestridge, 1996).

### 2.4 Formation of Virtual Teams

In the beginning, the need for virtual teams arose from the challenges faced by organizations that needed to collaborate among global experts who were unable to travel to get involved in the tasks and projects required of them. Gradually, and with the advent of better technological capabilities, virtual teamwork transformed to a point where virtual collaboration has become the norm for startups, national as well as global organizations.

By the early 2000s, studies began to reveal that fewer virtual teams formed during that period actually achieved their goals and team objectives when compared with traditional teams. Piccoli et al., (2004) shed more light on significant challenges these teams were facing in implementing virtual collaboration. A few years later, Brett et al., (2006) revealed that most teams and organizations considered virtual collaboration to be less productive than face-to-face communication, with half of his survey respondents being flustered by the virtual collaboration technology which at that time appeared complex. But as technology gradually advanced with simpler and more efficient collaborative tools being developed, people learned how to use those tools better, and the level of productivity and successes within virtual teams gradually increased.

There have however been mixed results from studies that explored the concept of virtual teams *(Table 3)* as well as the relationship between virtual teamwork and performance over the years. Some researchers found that virtual teams perform worse than face-to-face teams while others discovered that the virtual teams perform relatively better, and yet, others found no significant differences in performance across both types of teams (e.g. Purvanova, 2014: Gilson et al., 2015). A major reason for the mixed results has since been traced to the fact that much of these studies focused on the dichotomous view of virtuality, i.e. fully face-to-face versus completely virtual teams, rather than considering it as a continuum (Martins et al., 2004). This has proven important because very few teams exist at either end of the spectrum of fully face-to-face and fully virtual; most teams fall somewhere along the spectrum (Stagl et al., 2007).

*Table 3: Descriptions of Virtual Teams*

| | |
|---|---|
| **Geographically dispersed across different time zones** | **(Dafoulas and Macaulay, 2002, Shin, 2005, Wong and Burton, 2000, Nemiro, 2002, Peters and Manz, 2007, Lee-Kelley and Sankey, 2008)** |
| **Driven by common purpose** | (Bal and Teo (2001a); Shin (2005); Hertel et al.(2005); Gassmann and Von Zedtwitz (2003b); Rezgui (2007) |
| **Dependent on communication technologies** | (Nemiro, 2002, Peters and Manz, 2007, Lee-Kelley and Sankey, 2008) |
| **Engages cross-boundary collaboration** | Gassmann and Von Zedtwitz (2003b); Rezgui (2007); Precup et al. (2006) |
| **Characterized by temporary teams** | Paul et al., (2005) Wong and Burton (2000), Cascio and Shurygailo, 2003, Leenders et al., 2003) |

### 2.4.1 Benefits and Challenges of Virtual Teams

Thanks to information and communication technology, many virtual organizational teams are able to meet their goals and while there have been arguments highlighting the benefits of virtual teams such as huge cost savings, job satisfaction and flexibility of work hours and projects (Marotta, 2006), cross-organizational collaboration, speedy response (Arnison and Miller, 2002), reduction in market penetration duration (Rafaeli and Ravid, 2003), there have also been studies that highlight the limitations and challenges faced in virtual teams such as the common knowledge problem (Cramton, 2001), conflict (Hinds and Mortensen, 2005; Hinds, Bailley, 2003) trust (Jarvenpaa and Leidner, 1999; Sarker et. al., 2011), coordination delay (Cummings et al., 2009), barriers in information flow (Miles and Snow, 1986; Cohen and Bailey, 1997; Rosen et al., 2007), loss in innovation potential due to

geographical and cultural distances among members (Lojeski et al., 2006;2007), and losses incurred due to failure of communication media (Zigurs, 2003).

## 2.5 Defining Virtuality

Several researchers have used the term 'virtuality' as an abstraction of the phrase 'virtual reality' (Nabila, 2009) which is defined according to Merriam Webster as 'an artificial environment which is experienced through sensory stimuli provided by a computer…'. From this definition, virtuality refers to a technologically generated environment that substitutes and replaces real-life scenarios and activities. The essence of this is to create a virtual environment that simulates a face-to-face or physical experience and through this medium, users are able to interact, communicate and collaborate in a virtual setting (Davis et al., 2009).

The term 'virtuality' has since been used in numerous studies on virtual teams (see Table 3) and has most commonly been operationalized as the geographical dispersion of team members across location, time and/or organizational boundaries (Gilson et al., 2015) Also, Kirkman and Mathieu (2005) defined virtuality using three points of view: (a) the extent of use of virtual tools by a team in coordinating, communicating and executing team activities, (b) the value of information that the virtual tools provide and (c) how synchronous the virtual communication is within the team.

Since virtual teams are made up of individuals who are geographically dispersed and who communicate and collaborate with the use of information and communication

technologies (ICT), the extent to which they rely on these tools as well as the frequency of usage are indicators of their level of virtuality. Interestingly, during Covid-19, the understanding of "geographically dispersed" has changed to include people that may actually live and work very close to each other but still communicate virtually due to social distancing.

Some other researchers have even studied virtuality as the leveraging of technology (Martinez et al., 2009), and with the definition of virtuality being multivariate, (e.g, de Guinea, Webster & Staples, 2012), it has been used by researchers as an indicator of both geographic dispersion and usage of technology (Cohen & Gibson, 2003) Other searchers have also studied virtuality as an input (Kock & Lynn, 2012) or as a moderator (Andressen, Konradt, & Neck, 2012) in the IPO framework.

Virtuality has also been operationalized and measured in several ways. Kirkman, Rosen, Tesluk & Gibson, (2004) have measured virtuality based on geographic dispersion of team members and assessing how many times they met. Ganesh & Gupta (2010) measured virtuality based on media richness by calculating the percentage of team communication that occurs with the use of various communication technology tools (e.g. Rapp, Ahearn, Mathieu & Rapp, 2010)

Schweitzer & Duxbury (2009) made a compelling argument about the question of whether or not a team is virtual but to what extent the team is virtual. This is true since different organizations adopt different levels of virtuality in their teams, then team virtuality should exist, not dichotomously, but as a continuum (Griffith et al.,

2003, Martins & Schipzand, 2011). It is therefore logical that the extent to which a team depends on technology is a key determinant of the level of virtuality it possesses.

The nature and conceptualization of virtuality have received significant paradigm shifts since the beginning of the Covid-19 pandemic. Prior studies have conceptualized virtuality differently as can be seen in *Table 4*. Some conceptualizations have used geographical, organizational and temporal dispersion (Martins et al., 2004, Griffith et al., 2003, Field & O'Connor, 2005) to explain it. With research on virtuality still going on, several models are still being proposed to operationalize virtuality (Shaubroeck and Yu, 2017). For instance, Hoch and Dulebohn (2017) presented virtuality as a moderator of team characteristics on performance while Marlow et al., (2017) and Merschbrock and Munkvold (2015) provide mixed impacts of virtuality on team functioning.

With the need for social distancing due to the pandemic and in a bid to reduce the spread of the virus and flatten the curve, even teams that are not geographically dispersed can decide to work remotely or virtually despite being meters apart. This is in line with Kirkman and Matthieu's (2005) argument and has greatly impacted the conceptualization of virtuality to exclude geographical, time-bounded and temporal dispersion of team members. Rather, the use of computer-mediated communication tools in lieu of traditional (face-to-face) communication has now become the most important factor in defining virtuality.

Therefore, for the purpose of this study, this paper defines virtuality as *the proportion of the time spent on a project that team members work virtually or remotely.* (Kirman et al., 2002).

While teams, by definition, are formed by assembling individuals with different proficiencies to achieve a common goal, assembling teams can however be formed in several ways. Prior studies have considered the virtual team forming based on three basic designs: fully co-located teams, fully virtual and, and a hybrid of the two – which is referred to as 'hybrid teams' (Miloslavic et al., 2015).

*Table 4: Prior Conceptualizations of Virtuality Before Covid-19*

| Authors | Conceptualization of Virtuality |
|---|---|
| Kirkman et al. (2002) | The proportion of the time that team members work virtually, the location of members, and the proportion of the time that members devote to their virtual team. |
| Gibson and Cohen (2003) | The amount of reliance on electronically mediated communication and the degree of geographical dispersion |
| Kirkman et al. (2004) | measured based on geographic dispersion of team members and assessing how many times they met |
| Kirkman and Mathieu | The degree to which teams rely on virtual tools to carry out essential team processes. |
| Martins and Schilpzand (2011) | Reliance on 'globalness, virtualness, and teamness' |
| Webster and Staples (2006) | Distance and geographic dispersion of team members |
| Hosseini, Zuo, Chileshe & Baroudi (2015) | A holistic phenomenon that reflects to what degree deviations from face-to-face team conditions affect the quality of communications within the team in comparison to a face-to-face team. |

## 2.6 Studies on Virtual Teams

Several theories and constructs have been used over the years in the study of virtual teams research such as Adaptive Structuration Theory (Chidambaram et al, 1991: Majchrzak et al, 2000), Communication theories (Crampton, 2001), Contingency Theory (Galegher & Kraut, 1994), Task Media Fit and Task Circumplex Model (

Hollingshead et al., 1993), Media Richness Theory (Majchrzak et al, 2000), Media Synchronicity (Ramesh & Dennis, 2002) etc *(Table 5)*. The study of virtuality and team effectiveness were rooted in the Input-Process-Output (IPO) Model which has been seen from numerous literature as a veritable guide for studying effectiveness in teams (Bosch-Sijtsema et al., 2011; Penarroja et al., 2013)

*Table 5: Theoretical Foundations in Different Virtual Teams Research*

| Team Inputs<br>14 Theories | Team Processes<br>22 Theories | Team Outputs<br>22 Theories |
|---|---|---|
| **Members**<br>Big Five' Personality Model<br>Dialogue Theory | **Communication:**<br>Adaptive structuration theory<br>Media richness theory<br>Media synchronicity theory<br>Task-media fit theory<br>Team knowledge transfer model<br>Time, interaction and performance theory | **Task performance:**<br>Adaptive structuration theory<br>Business action theory<br>Contingency theory<br>Dialogue theory<br>Media richness theory<br>Network and organization form theory<br>Social information processing theory<br>Task circumplex model<br>Task-media fit theory |
| **Context**<br>Adaptive structuration theory<br>Contingency theory<br>Control theory<br>Learning theory<br>Media richness theory<br>Network and organization form theory<br>Role theory<br>Self-efficacy theory<br>Social identity or deindividuation theory<br>Social information processing theory<br>Team performance model<br>Time, interaction and performance theory. | **Social interaction:**<br>Adaptive structuration theory<br>'Big five' personality model<br>Conflict management behavior theory<br>Control theory<br>Dialogue theory<br>Media richness theory<br>Network ad organization form theory<br>Punctuated equilibrium model<br>Self-efficacy theory<br>Social comparison theory<br>Social identity or deindividuation theory<br>Social information processing theory<br>Social presence theory<br>Swift trust theory<br>Team performance model<br>Time, interaction, and performance theory | **Effectiveness:**<br>Adaptive structuration theory<br>Business action theory<br>Commitment theory<br>Conflict management behavior theory<br>Dialogue theory<br>Learning theory<br>Media richness theory<br>Media synchronicity theory<br>Punctuated equilibrium model<br>Self-efficacy theory<br>Social information processing theory<br>Task circumplex model<br>Time, interaction, and performance theory |

Schiller & Mandviwalla (2007)

# 3. Theory and Hypotheses

In this section, through the theoretical lenses of Adaptive Structuration theory (Desanctis and Poole, 1994) and Transformational Leadership Theory (Dionne et al., 2004; Bass & Avolio, 1994) for studying teams, this paper introduces the four key constructs to be used in the model which are leadership effectiveness, communication frequency, virtuality, and project performance.

In addition, this study examines how leadership, communication, virtuality and performance are interrelated within a project team setting. Specifically, this study delves into the individual relationships between leadership effectiveness and project team performance, communication frequency and project performance as well as how virtuality influences these individual relationships.

The next subsection will detail the proposed theoretical framework and model and how these four constructs are operationalized in the model by hypothesizing the relationships between the constructs.

## 3.1 Performance in Virtual Teams

Putting project teams into perspective, the successful accomplishment of project tasks hinges on effective communication within the team as well as the fostering of strong working relationships (Huemann, 2010).

It is general knowledge that the measure of any construct must be deeply rooted in theory, and team performance is no exception to this (Salas et al., 2003) as theoretical models impact the construction and utilization of measures (Jones, 1997). The measurement of team performance has been of major interest to researchers and

practitioners who need to appraise team strengths and weaknesses. (Salas et al.2003). It is not surprising however - considering how complex the construct of team performance is – that a clear and universally accepted definition and measurement of team performance still does not exist, even though numerous definitions of performance have been provided in diverse studies *(Table 6)*. Because of this complexity of this dependent variable, it easily gives way to the 'criterion problem' (Austin &Villanova, 1992). This 'problem' occurs when a criterion is based on weak theory and vague constructs. This implies that performance as a construct must be measured uniquely and differently using metrics adopted by different organizations and industries. According to Hackman (1990), there are three team performance elements namely: (1) the extent of team accomplishment of goals) (2) the extent of team satisfaction and commitment to goals and (3) the extent of team improvement.

As it relates to project teams however, it is essential that the project managers ensure clarity of project goals and success criteria after which performance metrics can be adopted for the team. In specific projects, for instance, a team's performance should be measured based on the team's achievement of the project goals and objectives. The performance standards to be used are often dependent on the organization's goals and should not contradict them. As a result, performance in projects can be measured by considering whether the project is executed and completed within the defined scope, time and budget (which are the project management triple constraints), while also achieving an acceptable quality that meets the needs of the organization and customer (PMI, 2013; Schwalbe, 2014). Traditionally, project management success is measured based on the team's ability to execute the

project within the triple constraints of project management and usually a fourth constraint, meeting client expectations is sometimes added. (Jugdev & Muller, 2005).

*Table 6. Definitions of Performance*

| Authors | Definition of Performance |
|---|---|
| Venkatraman & Ramanujam (1986) | Performance is the time test of any strategy. |
| Cordero (1989) | Effectiveness (i.e. measuring output to determine if they help accomplish objectives). Efficiency (i.e. measuring resources to determine whether minimum amounts are used in the production of these outputs). |
| Lebas (1995) | Performance is about deploying and managing well the components of the causal model that leads to the timely attainment of stated objectives within constraints specific to the firm and to the situation |
| Neely et al. (1995) | Efficiency and effectiveness of purposeful action |
| Rolstadas (1998) | Performance is a complex interrelationship between seven performance criteria: effectiveness, efficiency, quality, productivity, quality of work life, innovation, and profitability/budget-ability |
| Dwight (1999 | the level to which a goal is attained. |
| Hoffmann (1999) | An evaluated contribution to the attainment of organizational goals. |
| Hauber (2002) | The contribution of specific systems (organizational units of differing sizes, employees, and processes) to attain and validate the goals of a company. |
| Wettstein (2002): | The degree of stakeholder satisfaction. |
| EFQM (2003 | The level of attainment achieved by an individual, team, organization or process |
| Krause (2005) | The degree of the achievement of objectives or the potentially possible accomplishment regarding the important characteristics of an organization for the relevant stakeholders. |

*Source: Ghalem, Okar, Chroqui & Semma (2016)*

For the sake of this study, we define performance as *the measure of the achievement of objectives based on generally accepted and predetermined metrics such as scope, schedule, and budget for projects*. Within the context of project, performance can therefore be defined as the measure of achievement of project objectives with regard to schedule, cost and scope *(See Appendix A)*.

## 3.2 Leadership in Virtual Teams

Leadership has been defined by Weisban (2008) as the exertion of influence on the behaviors and attitudes of individuals and groups of people and is therefore the ability of an individual to influence or instill change and desirable character in others.

With more and more organizations and projects adopting and adapting to virtual teamwork, this new and quite complex virtual collaboration environment has given rise to the need for a more effective leadership to manage virtual teams (Hossein, 2012). The proliferation of virtual teamwork has put the project manager in new frontiers of leadership challenges which, if unequipped to tackle effectively, could put both the project manager and the team at risk of project failure (Liao, 2017). It is logical to expect a more difficult leadership in virtual teams when compared to face-to-face teams which is a result of a more computer-mediated approach to communication, collaboration, and teamwork.

Managing and leading virtual project teams therefore require a different approach in order to integrate the team, plan and coordinate project activities. Also, there have been arguments that what sets high performance virtual teams apart is the presence of highly effective team leaders who can propel and motivate the team in achieving and exceeding project deliverables (Piccoli et al., 2004). In view of these, leadership within a virtual team is important as it plays a central role in how the virtual team functions, while helping the team deal with challenges arising from virtual collaborations and adaptation of virtual teamwork (Marks, Zaccaro & Mathieu, 2000).

It is essential for virtual team leaders to understand and accept that there are significant differences between leading a traditional team and a virtual team, so as to ensure the application of a more appropriate leadership style to achieve project success in virtual teams (Turkay & Tirthali, 2010). Such leadership styles could be a blend of formal or informal approaches and could either be assigned or emergent in order to manage and ensure a high performing project team (Ebrahim et al., 2009).

Numerous literatures have described and presented various forms and styles of leadership applicable to different organizations and teams. Such leadership forms and styles have included emergent leadership (Carte, Chidambaram & Becker, 2006), leader-member exchange (Goh & Wasko, 2012), transformation and transactional leadership (Strang, 2011), cross-cultural leadership (Sarker, Sarker & Schneider, 2009), inspirational leadership (Joshi et al., 2009) among others. However, for the purpose of this study, and due to the nature of virtual teams, the transformational leadership theory has been found to be more appropriate in our study of virtual teams.

### 3.2.1 Transformational Leadership Theory

Transformational leadership has been found according to Balthazard, Waldman & Warren (2009) to stem from an individual's personality as well as communication style and can positively impact team performance and satisfaction (Porvanova & Bono, 2009) as well as team motivation (Andressen et al., 2012). It is a relationship-oriented leadership style that focuses on team relationship and enhances a restructuring of team members' dedication, vision, and commitment to the achievement of team goals (Riggio, 2009). Certain leadership traits such as influence, motivation, consideration,

and intellectual excitement help a transformational leader to inspire and motivate the team members to improve and attain a high level of performance (Dvir et al., 2002).

Transformational leadership in previous studies were measured based on the team members' evaluation of the leader's behavior in four distinct dimensions (Bass & Avolio, 1994; Pearce & Sims, 2002) which were: idealized influence (the level of enthusiasm the project manager employs in dealing with the team members), inspirational motivation (the extent to which the project manager inspires the team members to do more), individualized consideration (the manager's expectation of performance for specific team members) and intellectual stimulation (the ability of the project manager to propel the team members in thinking critically and unconventionally).

Shachaf & Hara (2005) also theorized four dimensions of effective virtual team leadership which are as follows:

1. Communication (the ability of the leader to communicate effectively with the team, ensure regular feedback and task clarification for closed-loop communication as well as promote prompt and regular interactions with the team)

2. Understanding (the sensitivity of the leader to individual team members' schedules, challenges, interests and opinions as well as knowing them on a personal basis).

3. Clarity of role (the ability of the leader to ensure clarity of individual and group roles and responsibilities, and his ability to exercise his authority in inspiring and mentoring the team)

4. Leadership attitude (the manner in which the leader asserts his influence on his team members by maintaining a positive, caring and collective attitude toward the team)

Based on the transformational leadership therefore, we propose a relationship between leadership effectiveness and team performance as it relates to projects as found in literature.

### 3.2.2 Leadership Effectiveness and Team Performance

According to Denison et al. (1995), an effective leader possesses the cognitive ability to identify and adapt to changes in their environment within their sphere of influence and this is a vital behavioral trait that is expected of a project manager in dealing with virtual teams. In any project team, the influence of an effective leader is pivotal to the success of the team and as this increases, an increase in positive team outcomes (team performance) is observed (Kozlowski et al., 1996; Kayworth & Leidner, 2001). It is expected that an effective leader possesses the required technical expertise for providing guidance and direction for the team members. Not only is this essential, it is also expected that the project manager is able to adapt to changes in the team structure and project characteristics, especially as it relates to a change in team collaboration and communication methods. We therefore hypothesize:

**Hypothesis 1:** In project teams, there is a positive relationship between leadership effectiveness and project team performance.

### 3.3 Communication in Virtual Teams

Virtual teams engage in computer-mediated communication with the use of technological tools and media to collaborate and communicate within and across teams. According to O'Reilly and Pondy (1979), communication is the exchange of information between two parties: a sender and a receiver, and the perceived meaning of the information being exchanged. This exchange has been identified as critical for working teams, including virtual teams. Hulnick (2000) pointed out that with technology being the bedrock of the virtual business relationship, communication is the cement that holds it together.

Communication is a very broad construct and lot of research has been done in communication and performance, but as Stout et al. (1994) argued, the relationship between the two have been inconsistent, partly due to the conceptualization of communication. This has led to different literature on several communication elements *(Table 5)* such as communication frequency (Marks et al.,2000), communication quality (González-Romá and Hernández, 2014), timeliness (Warkentin et al., 1997), closed loop communication (McIntyre and Salas, 1995) and communication content (Keyton, 1997). These distinct elements of communication within a team have a pivotal part to play in how information is transmitted, how the content is perceived and acted upon and how team activities are performed. Kolowski & Ilgen (2006) backed this up when he considered communication as an integral team process because of its influence on other processes that contribute to improved team performance.

Several studies since been conducted on communication and its relationship with team performance. For instance, a laboratory study conducted by Purvanova (2014) indicated that virtual teams tend to communicate less frequently in a laboratory setting, engaged less in knowledge sharing and exhibited lower levels of performance when compared to co-located teams. Communication has also been found to be a key predictor of several team outcomes such as improved performance and higher commitment (Ferrel & Herb, 2012).

In a bid to understand the distinct roles that communication elements play in project team performance, several communication elements that have been considered in prior studies are communication content, communication frequency and communication timeliness (Table 7). Communication content, sometimes referred to as communication style refers to the nature of the communication between individuals and team members and are classified into task-oriented and relational-oriented communication (Keyton, 1999). Communication frequency refers to how often information is shared within the team in a period. A higher frequency of information shared within a team according to (Marks et al., 2000) does not necessarily improve their performance and may in fact hinder the team's progress.

Closed-loop communication is a characteristic of communication wherein the information sender receives feedback from the receiver, ensuring that the information shared is well understood (McIntyre and Salas, 1995). Communication timeliness refers to the promptness of the information being shared and whether or not there is a delay in sending or receiving information relevant to the project (Warkentin et al., 1997).

*Table 7: Elements of Communication*

| Construct name | Definition | Related citation |
|---|---|---|
| Communication frequency | Volume of communication over any communication mode | Marks et al. (2000) |
| Communication quality | Clarity, effectiveness, accuracy and completeness of communication | Gonzalez-Roma & Hernandez (2014) |
| Communication timeliness | Extent to which communication is provided or received in a timely manner | Warkentin et al., (1997) |
| Closed-loop communication | a team member sends a message<br>another team member receives the message<br>iii. the original team member follows up to ensure it was received and understood | McIntyre & Salas (1995) |
| Communication content | Either task-oriented (i.e., communication focused on task completion or relational-oriented (i.e., communication of an interpersonal nature) | Keyton (1997) |

*Source: Marlow, Lacerenza & Salas (2016)*

For the sake of this study however, communication frequency, which is typically the volume of communication done within a team over any communication node will be considered. This element of communication is appropriate because due to the extra effort required to communicate through computer-mediated modalities (e.g., emails, video conferencing, telephones, etc), virtual teams must put in extra effort to manage high volumes of messages, which can hinder performance (Morrison-Smith & Ruiz, 2020)

### 3.3.1 Adaptive Structuration Theory (AST)

The Adaptive Structuration Theory (AST) by DeSanctis and Poole (1994), which is an extension of Anthony Giddens' (1979) "Structuration Theory" focuses on social structures and human interaction with the use of information technology within institutions. Simply put, it refers to the appropriation of technology for use by team

members or organization through the utilization of such technology to collaborate and execute tasks. AST posits that patterns and structures tend to arise from the technologies' features, spirit and intent, and these structures vary based on the on the tasks, environment, team setting as well as other contingencies that may arise. In other words, the adoption of the technology is structured by the users, teams, or organizations in different ways for achieving and accomplishing their tasks. Such adaptations of the technologies could be in the form of frequency, modes of usage, and customization to specific tasks, sometimes completely different from the designed intent of the technology.

Desanctis & Poole (1994) concluded that the technology usage and its structures vary across organizations and are just as influenced by the external environment as they are by the functionalities embedded in the technology itself. This observation is validated by the current use of communication technology by different project teams or organizations in effectively collaborating, interacting and accomplishing tasks during the Covid-19 pandemic. The Adaptive Structuration Theory is increasingly evident in the communication process of project teams particularly as these teams have been heavily impacted by the virtual world due to the pandemic and are rapidly modifying the use of these collaboration technologies to communicate and achieve the project goals.

Some of such appropriations of these technologies are evident in the frequency of use of these tools, such as telephones, emails, video conferencing and other means during the projects, and the frequency of the communication within the teams continuously impact how these projects perform eventually. In a bid to adapt to

societal, structural and communication changes that arose from the pandemic, organizations and teams have adapted communication technology in diverse ways. Especially with the rate of remote work having increased over the past two years, there has been an increase in communication frequency on the virtual spectrum and a reduction in face-to-face communication, with collaboration technologies being exploited and considered integral to project and organizational performance.

### 3.3.2 Communication Frequency and Team Performance

With several studies conducted around communication – which is what holds virtual teams together, team communication has been identified as a major factor affecting performance in virtual teams (Marlow et al., 2017). Being a very broad research area as well, it has been conceptualized differently by different researchers, and several communication elements that relate to team performance such as communication frequency (Marks et al.,2000), communication quality (González-Romá and Hernández, 2014), timeliness (Warkentin et al., 1997), closed loop communication (McIntyre and Salas, 1995) and communication content (Keyton, 1997) have been studied.

A common element of team communication that has been measured is communication frequency (sometimes referred to as communication volume) and with the reliance on computer-mediated communication by virtual teams, more and more information is being shared over a variety of channels, the volume and frequency of which tend to impact the performance of, and collaboration within the team. In other words, the overabundance or inadequacy of information being shared within a virtual team has a major impact on how the team eventually performs. This is why the measure

of communication important to this study and to virtual teams as a whole – due to their reliance on communication technology and the propensity to indulge in sharing either too much information (due to convenience) or too little information (due to asynchronicity) – is communication frequency.

***Communication frequency.***

Communication frequency relates to the volume of communication shared within a team through a variety of modes in a period of time. Literature findings have suggested that a higher volume or frequency of communication does not always equate to improved team performance (Marks et al., 2000). As a matter of fact, Espevik et al., (2006) found out that teams whose members are more familiar with each other achieve better performance than unfamiliar teams even with lower communication frequency. Conversely, Kratzer (2001) found that a low communication frequency in innovation teams may actually lead to higher performance as it is an indication of effectiveness of the team wherein there is little need for frequent clarifying information being shared. This perspective to communication frequency however depends on the type of information being shared within the team.

Due to the extra reliance of virtual teams on ICT tools for communication, they tend to put a lot more effort in sending and managing a larger volume of information (e.g. emails), leading to lower productivity and hindered performance.

Another dimension of communication frequency is in the number of times the teams hold meetings. Such meetings could include weekly meetings, impromptu

meetings, progress meetings and conflict resolution meetings. A higher volume of such meetings tend to reduce the time spent on actual project activities and can demotivate the team members, especially when those meetings are considered unnecessary and can be avoided. For instance, holding team meetings three times a week with the use of videoconferencing tools (eg. Microsoft Teams) can deflate the team members' enthusiasm for the project and can also be considered a waste of quality project time.

Communication frequency has been found to impact team development and team functioning for a new team, since more interaction between team members increases team bonding and cohesion, making it possible for team members to perform better. Desanctis and Monge (1998) found that an increase in electronic communication leads to an increase in communication frequency and ultimately reducing efficiency due to irrelevant information being shared. Also, excessive sharing of unnecessary information could result in cognitive overload and reduced performance (Chandler & Sweller, 1991). This increased communication frequency, particularly in highly virtual teams will lead to high volume of e-mails and messages within the virtual teams that could lead to information overload leading to poorer performance, whereas in less virtual teams, the communication being shared would be more of face-to-face and therefore less volume of e-mails and messages.

While negative relationships between communication frequency and team performance is prevalent in literature, some studies provided a divergent outlook. Bui et al. (2017) found a positive relationship between the frequency of communication and team performance in medium-sized teams but negative in small-sized teams. A more divergent outlook for example, exist in a much earlier study. Patrashkova-

Volzdoska et al (2003) found an inverted u-shaped curvilinear relationship between communication frequency and team performance. This study showed that a moderate level of communication frequency is more efficient than either low or higher communication frequencies. This curvilinear relationship has practical validity as too little information guarantees poor performance due to limited knowledge sharing and team building benefits accompanying the communication process, while too much information (with emails for instance) hampers performance especially due to the time spent sifting through lots of email to find relevant information. We therefore expect that, while maintaining a medium communication frequency within the team, the better the overall project performance of the team, while low and high communication frequency diminishes performance.

Thus:

> **Hypothesis 2:** In project teams, there is an inverted u-shape relationship between communication frequency and project team performance where lower and higher levels of communication frequency diminish performance while medium communication frequency improves performance.

### 3.4 Team Virtuality

As virtuality has been viewed as a continuum rather than dichotomous (Griffith et al., 2003), the degree of virtuality has then been operationalized as ranging from solely traditional (face-to-face) to solely virtual. Even though solely virtual teams exists, the majority of project teams fall within the continuum, with such teams being referred to as hybrid teams.

From the reviewed literature, the degree of team virtuality hinges on two criteria: time and distance. According to Schweitzer & Duxbury (2010), they theorized that the degree of virtuality in a team is a three-dimensional construct: the ratio of time the team spends working apart, the ratio of team members who work virtually and the degree of geographical dispersion of the team members.

Objective-focused measures of virtuality ask teams to estimate the proportion of time spent using specific technological tools (Maynard, Mathieu, Gilson, Sanchez, & Dean, 2019) or time spent working remotely/face-to-face (Golden & Veiga, 2005).

We focus on the spectrum of virtuality in teams, ranging from the traditional (face-to-face), known as low virtuality teams to completely virtual (or high virtuality) teams. Since the global adoption of technology, there realistically does not exist any project team that communicates and collaborates solely on a face-to-face basis, therefore, most teams will fall within the low virtuality – high virtuality spectrum. Social distancing does not eliminate the possibility of team members meeting face-to-face, rather it reduces co-location to a minimum and provides restrictions when necessary.

With this, the conceptualization of virtuality in this study will then depend on the extent of virtuality of these teams as being of higher virtuality (teams who spend a greater proportion of time collaborating virtually) or of lower virtuality (teams who spend a lesser proportion of time collaborating virtually). Also, according to Griffith et al., (2003), hybrid teams are: ‘composed of members who interact over time, according to the needs of the moment, and through media, with the amount of face-to-face

contact determined by their own adaptation and structuration of the process'. Many organizations operate in hybrid team arrangements (Iorio & Taylor, 2015, Mignone et al., 2016) and this is fully in line with my definition and conceptualization of virtuality.

### 3.4.1 Effect of Virtuality on Leadership Effectiveness and Project Performance

Leadership in a dispersed team is typically more difficult because effective leadership is dependent on quality formal and informal interactions that have been hindered due to distance within the team.

In studies on the interaction between leadership and virtuality, a relevant finding in Hoch and Kozlowski's (2012) study revealed that virtuality significantly diminished the relationship between leadership and performance in virtual teams as a result of the geographical dispersion between the leader and the team, while Henderson (2008) found that team members tend to be more satisfied with their leader, perceiving him to be much better at decoding messages while being geographically dispersed.

For example, as it relates to project planning – which is a major responsibility of the project manager – it is more difficult to plan project activities in a virtual setting where there is a great reliance on virtual collaboration tools. Physical aspects of planning which includes brainstorming, physical measurements, technical reviews, group activities and physical exertion are greatly hindered, rendering the project manager less able to properly lead the team. While face-to-face, or low virtuality teams offer easier coordination (Heun, & Blanchard, 2003), in high virtuality teams where virtual collaboration takes up a greater proportion of time spent on project activities, a leader may find it extremely difficult to motivate, inspire, manage and

coordinate the team due to the absence of rich communication media to physically assess project tasks, timelines, deliverables and track progress (Hackman & Walton, 1986). This virtual collaboration also impedes the project manager's ability to adequately determine the needs of the team and quickly respond to changes in project activities effectively. We therefore expect that the more time the team spends working virtually, the less effective the leadership will be, resulting in poorer overall project team performance. Thus,

> **Hypothesis 3:** In project teams, the positive relationship between leadership effectiveness and project team performance is weaker in higher virtuality teams than in lower virtuality teams.

### 3.4.2 Effect of Virtuality on Communication Frequency and Project Performance

Teams typically tend to communicate frequently with the use of technology; including traditional, hybrid and fully virtual teams. The use of such communication technology however does not depend so much on whether or not the teams are geographically dispersed or collocated. For instance, in traditional (or face-to-face) teams, the use of emails, mobile phones and collaboration software such as Jira, Confluence, Trello, etc remains commonplace, just as fully virtual teams use them. However, the proportion of work done remotely or virtually is expected to influence how these teams perform with the use of these technologies. Team members who do not get to communicate in the same space, but rely fully on technology to share, collaborate and interact due to geographical dispersion will experience a different level of performance when compared to teams that are in a collocated space, who get to communicate frequently among each other.

High virtuality teams are those whose team members spend a larger proportion of their time working remotely on their projects. A major characteristic of such teams is that they are technologically savvy and have developed efficiency in using technology to communicate and collaborate. This efficiency in collaboration is also due to the nature of the projects, or task type such teams embark on (Kock and Lynn, 2012; Rico and Cohen, 2005). Such teams tend to work on innovative projects with products that are not physical in nature.

More specifically, we argue that teams who spend less time collaborating remotely or in a virtual setting (low virtuality teams) and engage in either too little or too much communication within themselves will experience the hypothesized nonlinear relationship between communication frequency and performance , while high virtuality teams who spend more time working remotely will not exhibit the inverted-u effect on performance regardless of the frequency of their communication. This difference in relationship is solely due to the efficiency of communication built by these teams. These high virtuality teams, according to Mesmer-Magnus et al. (2011), have greater latitude for parsing information and reviewing responses before communicating them, which affords them the opportunity to better process information and communicate more efficiently than face to face teams. Another facet to the efficiency of communication in these high virtuality teams is that they tend to control the distribution of redundant information, particularly because unlike low virtuality teams, informal and non-project related communications are minimal. Therefore:

**Hypothesis 4:** In project teams, the inverted u-shape relationship between communication frequency and project team performance is moderated by the

degree of virtuality such that this shape is preserved only in lower virtuality teams while the inverted-u shape diminishes in higher virtuality teams.

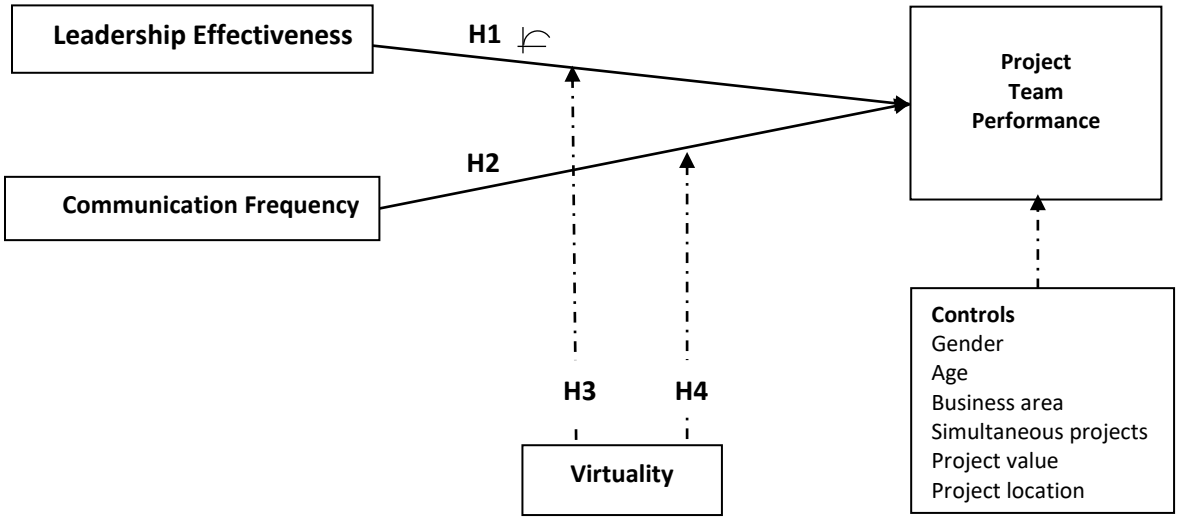
### 3.5 Proposed Theoretical Model

This research draws on Adaptive Structuration Theory and Transformational Leadership Theory as the basis for developing the model of teamwork, leadership, communication, and performance in virtual teams *(Figure 1)*. This model proposes that virtuality moderates the individual relationships between leadership effectiveness, and communication frequency on one hand, and project team performance on the other. This research model is considered at the project team member level where perceptions of team leadership characteristics and teamwork are subjective to each individual team member.

This study endeavors to prove that the relationships between leadership effectiveness and project performance, and between communication frequency and performance, are influenced by the proportion of time the team spends collaborating and communicating remotely or virtually. Specifically, this study expects that the leadership effectiveness of the project manager is weaker at higher levels of virtuality and reduces the performance of the team but expects that high levels of virtuality within the team will change the inverted-u relationship between the frequency of communication and team performance. In other words, virtuality is expected to be detrimental to the leadership effectiveness in high virtuality project teams and relatively different for communication within such team.

Technology-mediated communication tools are a major feature of virtual teams and helps the project team in communicating and collaborating effectively in lieu of traditional communication.

*Figure 1: Model of Leadership, Communication, Virtuality and Performance*




# 4. Research Method

## 4.1 Data Collection and Questionnaire Design

In testing our hypotheses, we made use of convenience sampling to gather some responses and also employed the services of an online market research company to collect data from participants who fit into the sampling frame for the study. The database of respondents was carefully filtered to fit the criteria of our study. We also made use of convenient sampling to gather responses from individuals who were willing

to participate in the study and who fit into the demographic of interest. The respondents reside within and outside Canada and consist of individuals from two major industries: engineering and construction, as well as finance and information technology. These two industries were specifically chosen because of the high volume of projects they engage in as well as the distinct differences in the ways their projects are approached. This sample included individuals who have worked remotely since the pandemic and have been part of project teams in their individual organizations.

We used the scale developed by Kacmar et al (2003) to assess the frequency of communication within the project team (α=.84). This scale was modified to fit project related activities by replacing the word 'memos' with 'emails', adding the frequency of communication using modern collaboration software, and asking how frequently emails are sent and received. This 7-item measure was scaled using a 5-point Likert scale to capture the frequency of the communication within the project team with 1 being never (zero frequency) and 5 being every day. This construct was operationalized as formative rather than reflective due to the presence of face-to-face communication items as well as computer-mediated communication items which are not considered interchangeable (see Appendix B for all measurement items).

Leadership effectiveness was also measured based on Lurey & Raisinghani (2001)'s team leadership items and using a 7-point likert scale ranging from 1 (Strongly disagree) to 7 (strongly agree) in assessing how effective the leadership of the team was during the project (α=.804).

Project performance was measured based on items developed by Lurey & Raisinghani (2001) capturing items such the team's effectiveness in reaching its goals, project objectives, timeliness of the project completion as well as its completion within budget. These items were scaled using a 7-point likert scale with 1 being strongly disagree to 7 being strongly agree(α=.82).

Virtuality, on the other hand, was measured using a two-item measure based on Schweitzer & Duxbury (2010)'s conceptualization of virtuality. This was achieved by measuring the proportion of work done remotely (virtually) based on the ratio of number of weekly hours spent working remotely to the total number of weekly hours spent on the project.

This measurement of virtuality refers to how much time the team spends working on the project virtually, relative to the total time the team members spend on the project. This dimension of virtuality helps to factor in the fact that sometimes, the project team members can choose to either work face-to-face or decide to work together remotely. Also, since most project teams fall into the hybrid team category, it is easier to measure their level of virtuality by assessing the proportion of time spent working virtually to the total time taken to complete the project.

The proportion of virtual work time was therefore calculated as the ratio of virtual work time to the total work time multiplied by 100. This measurement implies therefore that teams that meet only face to face will score zero on this dimension, while those who are purely virtual will score 100%.

These measures were captured using survey questions related to number of weekly work hours spent working remotely and the total number of weekly work hours spent working on the project.

We conducted a pretest of the survey instrument on several individuals who were not included in the initial sample or final survey. These respondents provided useful comments about the questionnaire and offered their opinions on the length, wording, and structure of the questions. Relevant feedback from these individuals were gathered and implemented in the final survey that was sent out.

## 4.2 Study Sample

We used Qualtrics, an online survey tool as our platform for building the online survey and to collect responses after obtaining approval from the Research Ethics Board. The questionnaire package contained a survey consent form that had to be agreed to before accessing the survey. A total of 300 surveys were distributed via email to potential respondents, and an additional 200 using the online market research company, making a grand total of 500 invitations sent. We gathered a total of 302 responses, with 102 from the email distribution, and 200 additional responses using the online market research company, making a response rate of 60.4%.

Data cleaning and screening procedures were conducted on the collected responses to ensure that the final data did not include incomplete or erroneous responses. There were responses that did not make logical sense, for instance, having the total number of hours spent working on the projects lower than the number of hours

spent working remotely on the project. Responses such as these, as well as those that had project descriptions that did not conform to the definition of “a project” were removed from the data. After the screening and cleaning process, we arrived at a total of 238 clean responses, making a final response rate of 47.6%.

The respondents were project managers and project team members in the field of engineering and construction, information technology, financial services, and education sectors. These respondents had been part of project teams within their organizations and at some point during the pandemic and most had to work remotely on their projects. (Figure 2a). The online survey was administered from February to March 2022 during the Covid-19 pandemic when a phased return to face-to-face activities had begun.

A summary of the sample demographics is presented in Table 8 and charts provided in Figure 2. A third of the respondents were female (32%) and most of the respondents fell within the age group of 30-39 years (37.4%). More than half of the respondents had Bachelors as their highest education obtained (54.2%) and roughly half of the respondents were project team members (45.4%). The organizational business area was almost evenly split with 47.9% in AEC (Architecture, Engineering and Construction), and 43.7% in Finance or IT related business areas. Roughly half of the projects in this study were valued above $250,000 (48.7%), while 39.5% of all projects were executed within one city.

Tables 20-23 in Appendix C provide frequency breakdown of the sample demographics, classifying the responses by project type with respect to age, education, project value, project location and project duration.

*Table 8: Sample Demographics*

| *Table 8: Sample Demographics*<br>**Demographic details** | | | |
|---|---|---|---|
| **Universe** N=238 | 100% | | |
| **Gender** | | **Organization's business area** | |
| Male | 67% | AEC (Architecture, Engineering & Construction) | 47.9% |
| Female | 32% | Financial Services/ Information Technology | 43.7% |
| Prefer not to say | 1% | Others | 8.4% |
| **Age** | | **Project value** | |
| Below 25 | 7.6% | Less than $50,000 | 16.4% |
| 25-29 | 26.9% | $50,0000-$250,000 | 34.9% |
| 30-39 | 37.4% | More than $50,000 | 48.7% |
| 40-49 | 18.1% | | |
| 50 and above | 10.1% | | |
| **Education Obtained** | | **Project locations** | |
| High School | 12.2% | Within one city | 39.5% |
| Undergraduate | 54.2% | Within one Province | 19.7% |
| Graduate (Masters) | 25.2% | In several Provinces in one country | 26.1% |
| Post Graduate (Doctorate) | 7.1% | In several countries | 14.7% |
| Others | 1.3% | | |
| **Project role** | | **Simultaneous projects** | |
| Project Team member | 45.4% | 1 project at a time | 16.8% |
| Project coordinator/supervisor | 18.5% | 2 projects at a time | 37.8% |
| Project Manager | 21.8% | 3 projects at a time | 23.5% |
| Program Manager/Director | 5.9% | More than 3 projects at a time | 21.9% |
| Others | 8.4% | | |

*Figure 2: Sample Classifications*

Figure 2a : Age Classification

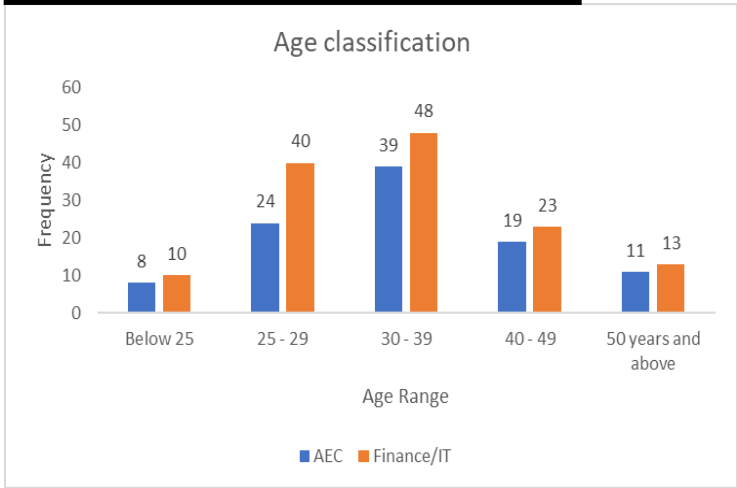


Figure 2b: Industry Classification

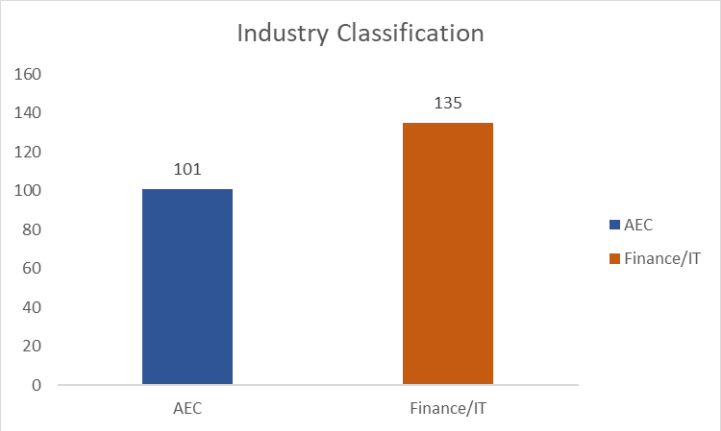



Figure 2c: Project Value Classification

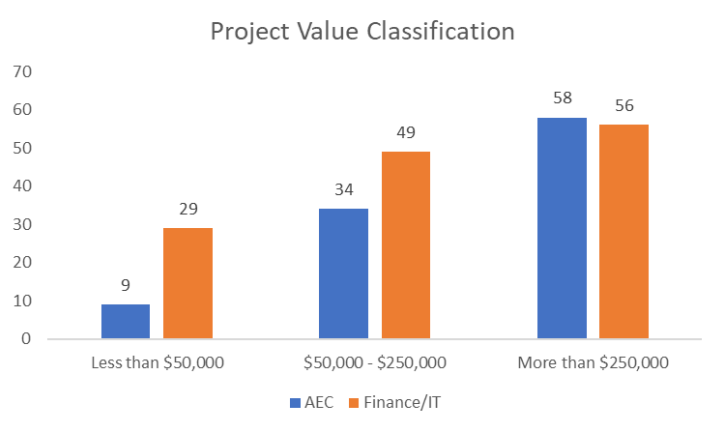



Figure 2d: Project Location Classification

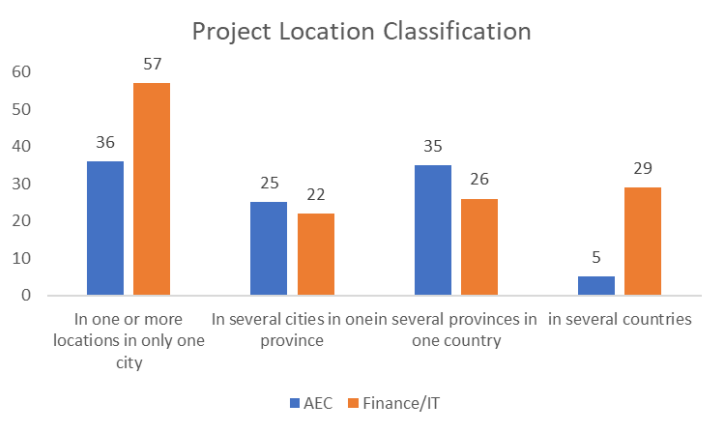
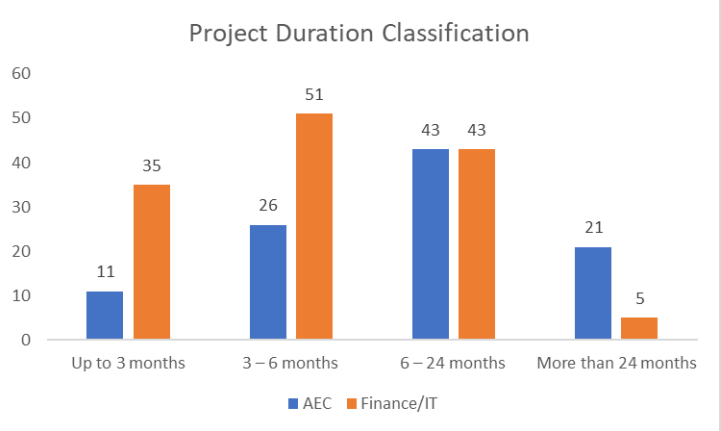



Figure 2e: Project Duration Classification



## 4.3 Measurement and Validation of Constructs.

Established scales from existing literature were used for all items. A major challenge for questionnaire-based surveys is the possibility of the existence of common method bias (or variance). To test for this, we used the Harman's one factor test as suggested by Podsakoff et al. (2003) and Gabrielsson et al. (2012). The principal components extraction method in SPSS exploratory factor analysis was used, and the results showed that 32.102% of the variance was accounted for by the first component while the extracted factors were responsible for 73.232% of the total variance extracted. Since there were 5 factors that had Eigenvalues greater than 1, and a dominant factor did not exist, we concluded that there was no common method bias threat in the data.

Fornell and Lacker (1981) recommended the use of the Average Variance Extracted (AVE) factor to assess the convergent validity of constructs and recommended an acceptable value of ≥ 0.50. The AVE typically reflects the amount of variance in the measurement items that is accounted for by the construct, which typically should be at least 50%. Internal consistency was also measured using the Cronbach's Alpha values with a recommended value of ≥ 0.70 (Hair et al. 2013). All the tests were two-tailed, with a 95% confidence interval, having a p-value below 0.05 as an indicator of statistical significance.

The project performance (α=.831) and leadership effectiveness (α=.804) scales indicated high internal consistency, exceeding the recommended 0.70 value (Table 9). We also observed that the communication frequency construct was formative in nature, having indicators that defined the construct, unlike reflective indicators that manifest

the characteristics of the construct. Further analysis recommended by Straub et al.(2004) were used to confirm the formative nature of the communication frequency construct.

*Table 9: Constructs and measurement items**

| | Factor Loadings |
|---|---|
| ***Project Performance (α=.831, CR=.83, AVE=.59)*** | |
| Has been effective in reaching its goals | .898 |
| Generally meets its project objectives | .847 |
| Is generally on time when it completes its work | .776 |
| Generally completes its work within budget | .768 |
| Has not been effective in reaching its goals (RC) | .558 |
| | |
| ***Leadership Effectiveness (α=.804, CR=.79, AVE=.56)*** | |
| The Project Leader offered new ideas or approaches to do our jobs better | .652 |
| The team members felt that the Project Leader was not helpful and supportive (RC) | .562 |
| The Project Leader made sure that the team members had clear goals to achieve | .829 |
| The Project Leader kept individuals working together as a team | .892 |
| | |

Notes: CR=construct reliability; AVE=average variance extracted; α=Cronbach's alpha

In validating the formative construct for communication frequency prior to data collection, Straub et al., (2004) recommended Q-sorting or Expert Validation to assess these measures while Petter et al. (2006) recommended evaluating the construct items based on theory. After collecting data, the formative construct was further validated by assessing the construct validity with SPSS Statistics using principal components analysis (Table 10) as recommended by Diamantopoulos and Winklhofer (2001), Bollen and Lennox (1991) and Chin (1991). The KMO, known as the Kaiser-Meyer-Olkin measure of sampling adequacy was used to measure the strength of the partial correlations between variables and the accepted value for KMO should be greater than 0.5. Also, the Bartlett's Test of Sphericity was used to confirm the null hypothesis of the correlation matrix being an identity matrix. This hypothesis testing was expected to show statistical significance for the null hypothesis. The formative construct showed KMO(.654)>.5 and significant Bartlett's Test of Sphericity ($p<0.001$). In the total

variance explained, 3 factors accounted for 82.83% variance within the construct, with the weights being statistically significant. All items were kept, preserving the content validity of the construct (Bollen and Lennox, 1991).

The communication frequency items factored into three components which we interpreted as: (1) communication using virtual software (2) email communication, and (3) face to face communication as can be seen in Table 10. These items are considered to be unique and not interchangeable, and they capture different facets of communication frequency thereby reinforcing the operationalization of the construct as formative.

*Table 10: Principal component (Communication Frequency items)*

| | Component | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| CF – Call your project team members using virtual collaboration software on project related issues? | **.884** | | |
| CF – Receive calls using virtual collaboration software from your project team members regarding the project? | **.850** | | |
| CF - Meet using virtual collaboration software such as Zoom, MS Teams etc? | **.845** | | |
| CF – Send project related emails to project team members? | | **.919** | |
| CF – Receive project related emails from your project team members? | | **.888** | |
| CF – Engage in physical (in-person) discussions with project team member(s) either formally or informally? | | | **.916** |
| CF – Attend project meetings physically in the office? | | | **.910** |

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.

In evaluating the reliability of the formative communication frequency construct, the VIF values for the communication frequency construct were also found to be below 2.0, eliminating the existence of multicollinearity in the construct (Hair et al.,1995).

We were able to perform reliability and confirmatory factor analysis for leadership effectiveness and project performance and each of the items loaded well on their individual constructs.

Being reflective constructs, the leadership effectiveness and project performance constructs on the other hand showed high internal consistency with Cronbach's alphas above 0.7 and high construct reliability with a composite reliability (CR) of above 0.7(Nunnally, 1978). Leadership effectiveness had high internal consistency with a Cronbach's alpha of 0.804, construct reliability (CR) of 0.79, and adequate convergent validity with AVE estimate of 0.56. Also, project performance showed adequate internal consistency, convergent validity, and construct reliability estimates ($\alpha$=0.831, CR=0.83, AVE=0.59). The significant factor loadings for the measurement items were also indicative of the scales' convergent validity (Gerbing and Anderson, 1988) and with average variance extracted (AVE) of above 0.5.

For further analysis, we calculated the mean scores of the individual constructs based on their constituent items. This is in line with Hair et al.'s (1995) suggestion of using this method for ensuring replicability of the measures. A visual examination of the standardized plots for each of the predictor variables indicated normal distribution, and also did not indicate any violation of homoscedasticity. The variance inflation

factor (VIF) scores were also observed to be below 5, indicating no threat of multicollinearity. These assumptions had to be confirmed from the data before proceeding to analyze the model

Table 11 provides the descriptive statistics and correlations of the variables used in this study using the bivariate correlation analysis. The results showed that the predictor variables: communication frequency and leadership effectiveness were positively correlated with project performance, with communication frequency having an insignificant but strong positive correlation with project performance (0.82, p=.209. This is the case because of the linearity of the Pearson's correlation, but communication frequency was found to have a nonlinear relationship with project performance. Leadership effectiveness was found to have a highly significant moderate correlation with project performance (0.57, p<.001) and virtuality also had a weak but highly significant positive correlation with project performance (0.24, p<0.01). As expected, there were weak correlations between the predictor variables; communication frequency and leadership effectiveness had weak negative correlations with each other (-0.03,p=608). Virtuality also had weak positive correlations with communication frequency (0.12, p=.077), leadership effectiveness (.15, p=.017), and project performance (.24, p<.001)

*Table 11: Descriptive statistics and correlations (N=238)*

| | Variable | Mean | SD | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Project Performance | 5.51 | 0.96 | 1.00 | | | | | | | | | |
| 2 | Communication Frequency | 2.41 | 0.62 | **0.82**$^{ns}$ | 1.00 | | | | | | | | |
| 3 | Leadership Effectiveness | 5.22 | 1.02 | **0.57**** | -0.03 | 1.00 | | | | | | | |
| 4 | Virtuality | 0.84 | 0.24 | **0.24**** | 0.12 | 0.15* | 1.00 | | | | | | |
| 5 | Business Area (Engineering) | 0.42 | 0.50 | 0.03 | -0.06 | 0.04 | **0.24**** | 1.00 | | | | | |
| 6 | Gender (1=Female) | 0.33 | 0.47 | 0.11 | 0.20 | 0.09 | 0.16* | 0.08 | 1.00 | | | | |
| 7 | Project Cost ($50k-$250k) | 0.35 | 0.48 | -0.06 | -0.04 | -0.07 | -0.08 | 0.02 | -0.08 | 1.00 | | | |
| 8 | Age | 2.96 | 1.08 | 0.15* | 0.21** | 0.11 | -0.01 | 0.02 | -0.18** | 0.05 | 1.00 | | |
| 9 | Two Simultaneous Projects | 0.38 | 0.49 | 0.06 | -0.03 | 0.01 | -0.02 | 0.09 | 0.03 | 0.14* | -0.09 | 1.00 | |
| 10 | Projects in several countries | 2.16 | 0.36 | 0.04 | -0.04 | 0.02 | 0.03 | 0.18** | 0.11 | -0.18** | -0.12 | 0.09 | 1.00 |

***p<.001;**p<.01; *p<.05;$^{+}$P<.10; ns=not significant

We controlled for the gender of the project team members and leaders with a dummy variable (female=1). We also controlled for the business area with both AEC (Architecture, Engineering & Construction) projects and FSIT (Financial Services/Information Technology) projects as business areas have been found to impact how projects are performed (Cui et al., 2018). Age of the project team members was captured using five categories ranging from 1 representing ages below 25, to 5 representing ages 50 and above. Also, since larger projects are typically more difficult to manage (Pressman, 2001), which in turn influences the project performance, we used project value (in USD) as a reflection of project size, which was measured using three categories ranging from 1=Less than $50,000; 2=Between $50,000 and $250,000 and 3=More than $250,000. We controlled for the number of simultaneous projects being executed by the team, which is likely to lead to team members struggling with high priority projects when they have an array of projects being executed at the same time. (Oppenauer & Van De Voorde, 2018).

## 4.4 Linear Regression for Hypothesis Testing

We conducted multiple linear regression tests to analyze our data and validate the correlations. The control variables were first regressed against the dependent variable and held constant throughout the analysis to assess their influence on the outcomes. We controlled for the business area of the project's organization, the gender of the respondents, the project cost, the age of the project team members, the number of projects being executed simultaneously as well as the geographical distribution of the projects.

In testing our hypotheses for the main effect of leadership effectiveness on project performance – hypothesis 1, we regressed leadership effectiveness variable on project performance and the control variables.

Because we hypothesized a nonlinear (inverted-u) relationship between communication frequency and project performance (hypothesis 2), we also regressed a squared term for communication frequency on project performance. We used the following equation to test for the quadratic-by-linear interaction (hypothesis 4) between communication frequency (CF) and virtuality (V) :

$$Y = \beta_0 + \beta_1 CF + \beta_2 CF^2 + \beta_3 VT + \beta_4 CF*VT + \beta_5 CF^2*VT$$ (Aiken and West, 1991)

We made use of the full regression model below for both leadership effectiveness (LE) (hypotheses 1 & 3) and communication frequency (CF) (hypotheses 2 & 4) :

$$Y = \beta_0 + \beta_1 CF + \beta_2 CF^2 + \beta_3 VT + \beta_4 CF*VT + \beta_5 CF^2*VT + \beta_6 LE + \beta_7 LE*VT$$

Where: $\beta_{i=1-7}$ = Regression weights
Y = Project Performance
CF = Communication Frequency
LE = Leadership Effectiveness
VT = Virtuality

In conducting moderated regression to test for moderating effects, we made sure to mean center the interacting variables (Aiken and West, 1991), which included the independent variables and the moderator to produce standardized product terms.

All the independent variables were entered into the regression model using hierarchical regression in six blocks. The first block contained the control variables as outlined earlier. In blocks two and three, the linear and quadratic terms of communication frequency, CF and $CF^2$ respectively were entered into the model as well as the linear term for leadership effectiveness, LE. Block four contained the moderator, VT, which is virtuality, while in block five, we entered the product terms CF*VT and LE*VT representing the linear interaction effects of communication frequency and virtuality, and leadership effectiveness and virtuality respectively. Finally, we entered $CF^2$*VT in block six to detect the non-linear (inverted-u) interaction effects of virtuality on communication frequency.

## 4.5 Results

### 4.5.1 Multiple Regressions

We conducted the hypothesis testing to see if there was support for the relationships among the constructs in the model (Chin and Newsted, 1999).

The multiple regression analysis was conducted using the enter method to obtain the best fit by adding the group of variables in blocks into the regression model to explain the most variance in the dependent variable (Project performance). In Table 12, we provided summary results of multiple regression tests and model 4 was found to have the best fit ($F=12.509$, $p=0.001$) with all variables entered in the model and collectively explaining 42.1% of the variance in project performance. Thus, we use model 4 for testing the hypothesis.

The regression results for the models are outlined in Table 13. Model 1 contains just the control variables, model 2 includes the direct effects, model 3 includes just the moderator, while model 4 adds the moderating effects of virtuality. For all four models, the variance inflation values were less than 2.5, which is significantly lower than the threshold of 5.0 (Studenmund, 1992), indicating that there was no issue of multicollinearity in the study.

Also, to rule out multicollinearity in the regression, we confirmed the VIF values on the final regression model (Table 14) which showed that all VIF values were below 5, thereby indicating the absence of multicollinearity (Field, 2009).

In hypothesis 1, we predicted that in a project team, the more effective the leader or project manager is, the better the overall project team performance. We found support for this hypothesis ($ß=.512$, $p<.001$).

*Table 12: Summary results of multiple regression enter method*

| Model | R | $R^2$ | Adjusted $R^2$ | S.E | Change Statistics | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | $\Delta R^2$ | $\Delta F$ | df1 | df2 | Sig. $\Delta F$ |
| 1 | .229[a] | 0.053 | 0.028 | 0.94930 | 0.053 | 2.135 | 6 | 231 | 0.050 |
| 2 | .596[b] | 0.355 | 0.329 | 0.78844 | 0.302 | 35.626 | 3 | 228 | 0.000 |
| 3 | .614[c] | 0.378 | 0.350 | 0.77622 | 0.023 | 8.233 | 1 | 227 | 0.005 |
| 4 | .649[d] | 0.421 | 0.387 | 0.75386 | 0.043 | 5.555 | 3 | 224 | 0.001 |

a. Predictors: (Constant), Several Countries, 2 Projects, Female=1, Eng/Const, What is your age group?, $50k - $250k
b. Predictors: (Constant), Several Countries, 2 Projects, Female=1, Eng/Const, What is your age group?, $50k - $250k, Zscore(LEF), ZCF_Sq, Zscore(CF)
c. Predictors: (Constant), Several Countries, 2 Projects, Female=1, Eng/Const, What is your age group?, $50k - $250k, Zscore(LEF), ZCF_Sq, Zscore(CF), Zscore(VT)
d. Predictors: (Constant), Several Countries, 2 Projects, Female=1, Eng/Const, What is your age group?, $50k - $250k, Zscore(LEF), ZCF_Sq, Zscore(CF), Zscore(VT), ZLEFxZVT, ZCFxZVT, ZCF_SqxZVT

*Table 13a: Regression analysis results: Communication frequency (N=238)*

| **Communication Frequency** | Model 1 | Model 2 | Model 3 | Model 4 |
|---|---|---|---|---|
| Constant | 4.914*** | 4.992*** | 5.034*** | 5.189*** |
| Gender (1=Female) | .288* | .249 | .180 | .200 |
| 2 simultaneous projects | .159 | .202 | .215 | .160 |
| Age | .165* | .164** | .167** | .130* |
| Project value ($50k-$250k) | -.140 | -.144 | -.110 | -.112 |
| Business Area (Engineering) | .015 | .042 | -.067 | -.058 |
| Multinational projects | -.031 | -.034 | -.009 | -.039 |
| Communication Frequency | | .056 | .031 | -.022 |
| Communication Frequency$^2$ | | -.090* | -.092* | -.130** |
| Virtuality | | | .228*** | .094 |
| Communication Frequency x Virtuality | | | | .015 |
| Communication Frequency$^2$x Virtuality | | | | .166*** |
| R-Square | .053 | .077 | .127 | .169 |
| R-Square change | | .024$^+$ | .050*** | .041** |
| F | 2.135* | 2.374* | 3.687*** | 4.164*** |

*Table 13b: Regression analysis results: Leadership effectiveness (N=238)*

| **Leadership effectiveness** | Model 1 | Model 2 | Model 3 | Model 4 |
|---|---|---|---|---|
| Constant | 4.914*** | 5.114 | 5.174 | 5.172 |
| Gender (1=Female) | .288* | .175 | .130 | .128 |
| 2 simultaneous projects | .159 | .132 | .142 | .134 |
| Age | .165* | .098* | .099* | .104* |
| Project value ($50k-$250k) | -.140 | -.059 | -.037 | -.038 |
| Business Area (Engineering) | .015 | -.018 | -.093 | -.070 |
| Multinational projects | -.031 | -.031 | -.012 | .024 |
| Leadership Effectiveness | | .524*** | .503*** | .510*** |
| Virtuality | | | .159** | .125* |
| Leadership Effectiveness x Virtuality | | | | -.154** |
| R-Square | .053 | .339 | .364 | .384 |
| R-Square change | | .287*** | .024** | .021** |
| F | 2.135* | 16.867*** | 16.354*** | 15.809*** |

*Table 13c: Regression analysis results: Full Model (N=238)*

| **Full Model** | Model 1 | Model 2 | Model 3 | Model 4 |
|---|---|---|---|---|
| Constant | 4.914*** | 5.224*** | 5.242*** | 5.352*** |
| Gender (1=Female) | .141* | .070 | .050 | .058 |
| 2 simultaneous projects | .080 | .082 | .087 | .062 |
| Age | .059** | .098 | .104+ | .079 |
| Project value ($50k-$250k) | -.070 | -.028 | -.018 | -.020 |
| Business Area (Engineering) | .008 | .010 | -.037 | -.023 |
| Multinational projects | -.011 | -.188 | -.004 | -.002 |
| Leadership Effectiveness **[H1]** | | .540*** | .517*** | .512*** |
| Communication Frequency | | .091 | .072 | .028 |
| Communication Frequency$^2$ **[H2]** | | -.102+ | -.106+ | -.152** |
| Virtuality | | | .160* | .026 |
| Leadership Effectiveness x Virtuality **[H3]** | | | | -.128* |
| Communication Frequency x Virtuality | | | | .007 |
| Communication Frequency$^2$ x Virtuality **[H4]** | | | | .206** |
| R-Square | .053 | .355 | .378 | .421 |
| R-Square change | | .302*** | .023* | .043** |
| F | 2.135* | 13.939*** | 13.766*** | 12.509*** |

Notes: Unstandardized coefficients (two-tailed p-values) ***p<.001;**p<.01; *p<.05;+P<.10

*Table 14: Summarized results of hypotheses testing using linear regression*

| | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. | Collinearity Statistics | |
|---|---|---|---|---|---|---|---|
| | B | Std. Error | Beta | | | Tolerance | VIF |
| (Constant) | 5.352 | 0.179 | | 29.864 | 0.000 | | |
| Gender (1=Female) | 0.118 | 0.109 | 0.058 | 1.082 | 0.280 | 0.906 | 1.104 |
| 2 simultaneous projects | 0.123 | 0.105 | 0.062 | 1.168 | 0.244 | 0.912 | 1.096 |
| Age | 0.071 | 0.049 | 0.079 | 1.428 | 0.155 | 0.846 | 1.182 |
| Project value ($50k-$250k) | -0.040 | 0.107 | -0.020 | -0.373 | 0.710 | 0.914 | 1.095 |
| Business Area (Engineering) | -0.045 | 0.105 | -0.023 | -0.430 | 0.668 | 0.890 | 1.124 |
| Multinational projects | -0.005 | 0.146 | -0.002 | -0.031 | 0.975 | 0.893 | 1.120 |
| Communication Frequency | 0.027 | 0.053 | 0.028 | 0.509 | 0.611 | 0.855 | 1.170 |
| Communication Frequency$^2$ | -0.089 | 0.033 | -0.152 | -2.665 | 0.008 | 0.798 | 1.253 |
| Leadership Effectiveness | 0.493 | 0.051 | 0.512 | 9.694 | 0.000 | 0.928 | 1.078 |
| Virtuality | 0.025 | 0.062 | 0.026 | 0.402 | 0.688 | 0.619 | 1.615 |
| Communication Frequency x Virtuality | 0.007 | 0.057 | 0.007 | 0.124 | 0.901 | 0.898 | 1.114 |
| Communication Frequency$^2$ x Virtuality | 0.126 | 0.042 | 0.206 | 2.997 | 0.003 | 0.548 | 1.824 |
| Leadership Effectiveness x Virtuality | -0.133 | 0.055 | -0.128 | -2.411 | 0.017 | 0.919 | 1.088 |

For hypothesis 2, we predicted an inverted-u relationship between communication frequency and project performance wherein from low to medium frequency of communication within the project team, the team experiences an increase in performance, while as the communication frequency within the team continues to increase, the project performance dips. As expected, we found significant support for this hypothesis (β= -.152, p=.008).

In model 4, we found supports for the moderation effects in hypotheses 3 and 4: the leadership effectiveness – project performance and communication frequency – project performance relationships were moderated by virtuality such that the positive relationship between leadership effectiveness and project performance was weaker in higher levels of virtuality (β=-.128, p=.017), while the inverted-u relationship between medium communication frequency and project performance was flatter in higher levels of virtuality (β=.206, p=.003). High virtuality teams were not found to exhibit an inverted-u relationship with project performance, as this kind of relationship was only preserved in low virtuality teams.

The results showed support for all four hypotheses related to both communication frequency and leadership effectiveness (Table 15).

*Table 15:* ***Hypotheses***

| | |
|---|---|
| **Hypothesis 1: In project teams, there is a positive relationship between leadership effectiveness and project team performance.** | **Supported (β=.512, p<.001)** |
| **Hypothesis 2: In project teams, there is an inverted u-shape relationship between communication frequency and project team performance where lower and higher levels of communication** | **Supported (β= -.152, p=.008)** |

| | |
|---|---|
| **frequency diminish performance while medium communication frequency improves performance.** | |
| **Hypothesis 3: In project teams, the positive relationship between leadership effectiveness and project team performance is weaker in higher virtuality teams than in lower virtuality teams.** | **Supported (β= -.128, p=.017)** |
| **Hypothesis 4: In project teams, the inverted u-shape relationship between communication frequency and project team performance is moderated by the degree of virtuality such that this shape is preserved only in lower virtuality teams while it becomes flat in higher virtuality teams.** | **Supported (β=.206, p=.003)** |

## 5. Discussion

In this study, we examined the roles that communication frequency and leadership effectiveness play in project team performance as well as how the proportion of project work done virtually (or remotely) influences these relationships. Project managers are constantly evolving and adapting to environmental, social, cultural, and economic changes, meaning that there is a crucial need to understand what factors influence project performance. The Covid-19 pandemic has changed the way project teams communicate and has weighed heavily on how project leaders manage their teams effectively. We argue that the element of virtuality has a huge part to play in project performance when considering how leaders manage their project teams and how frequently these teams communicate. Tables 16 and 17 show the extent to which both AEC and finance/IT projects adopted virtual work during the pandemic, revealing the frequency of team members that worked remotely, as well as the proportion of remote work they engaged in. In this table, we found that financial services/IT teams were typically more virtual than AEC teams due to the nature of their projects. 13.5% of IT teams worked remotely on their projects up to fifty percent of

the time, while 85.5% worked on their projects more than fifty percent of the time (with 75% of the project work being fully virtual) as observed in Tables 16 & 17.

*Table 16: Virtuality in Finance/IT projects.*

| Proportion of virtual work | | Frequency | Percent | Cumulative Percent |
|---|---|---|---|---|
| | .25 | 2 | 1.5 | 1.5 |
| | .33 | 4 | 3.0 | 4.5 |
| | .50 | 12 | 9.0 | 13.4 |
| | .67 | 5 | 3.7 | 17.2 |
| | .75 | 10 | 7.5 | 24.6 |
| | 1.00 | 101 | 75.4 | 100.0 |
| | Total | 134 | 100.0 | |

*Table 17: Virtuality in AEC projects*

| Proportion of virtual work | | Frequency | Percent | Cumulative Percent |
|---|---|---|---|---|
| | .25 | 10 | 9.9 | 9.9 |
| | .33 | 5 | 5.0 | 14.9 |
| | .50 | 15 | 14.9 | 29.7 |
| | .67 | 11 | 10.9 | 40.6 |
| | .75 | 11 | 10.9 | 51.5 |
| | 1.00 | 49 | 48.5 | 100.0 |
| | Total | 101 | 100.0 | |

## 5.1 Communication Frequency – Project performance relationship

One of the four important aspects of communication is the frequency of communication, with the others being content, form and direction (Frazier and John, 1984). We present empirical evidence that the effect of virtuality on communication frequency and project performance is two-fold. First, this study demonstrates that high virtuality project teams (that spend more time working virtually on their projects) tend to experience better project performance—irrespective of the frequency of their communication—than teams that spend more time working face to face or in a co-

located space (Table 18). This was observed from the mean performance levels of Finance/IT projects ($\bar{x}$=5.597; SD=0.911) compared to AEC projects ($\bar{x}$=5.372; SD=1.014).

The higher performance levels experienced by these high virtuality teams compared to lower virtuality teams as seen in Table 18 can be traced to several factors: the ease of access to information that the technological tools provide, the wider communication channels afforded by the team, fewer resources wasted in calling physical meetings, transporting, and accommodating team members, and the nature of the project deliveries (which are typically intangible in nature).

*Table 18: Measures of central tendency based on project types*

| **Finance/IT** | Project Performance | Leadership Effectiveness | Communication Frequency | Virtuality |
|---|---|---|---|---|
| N | 134 | 134 | 134 | 134 |
| Mean | 5.5970 | 5.2575 | 2.4254 | .8930 |
| Std. Deviation | .91075 | 1.01813 | .63368 | .20428 |
| Range | 5.00 | 5.00 | 3.43 | .75 |
| | | | | |
| **AEC** | Project Performance | Leadership Effectiveness | Communication Frequency | Virtuality |
| N | 101 | 101 | 101 | 101 |
| Mean | 5.3723 | 5.1337 | 2.3918 | .7550 |
| Std. Deviation | 1.01510 | 1.01400 | .59201 | .27280 |
| Range | 4.60 | 4.75 | 3.29 | .75 |

As can be seen from Table 19, both project types experienced changes in project performance during the Covid-19 outbreak. Finance/IT projects experienced better project performance during the lockdowns (Mean=5.4851, SD=.98562) than they did before the pandemic (Mean=5.5970, SD=.91075), while AEC projects experienced the

opposite; better performance before the pandemic (Mean=5.4678, SD=.85708) than during the lockdowns (Mean=5.3723, SD=1.01510).

This is not unexpected as AEC projects that typically engage in more face-to-face collaboration were constrained due to the social distancing mandate during the pandemic, leading to a dip in project performance. On the other hand, Finance/IT projects experienced better project performance during the pandemic, as they are typically high virtuality in nature, and the rapid improvement in virtual collaboration technologies and software capabilities during the pandemic made it easier for these teams to exploit the resources and achieve more success within that period.

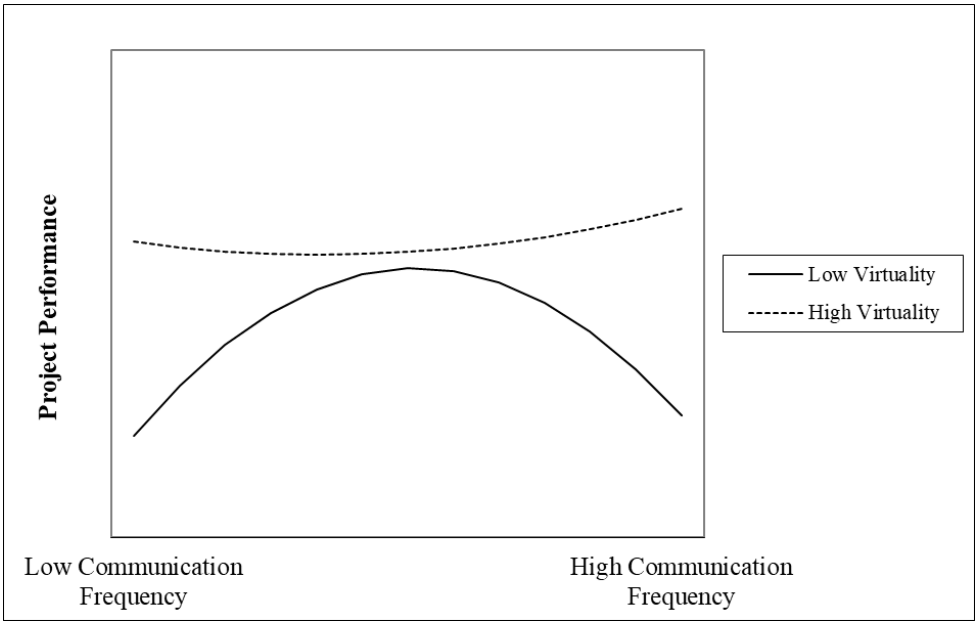
*Table 19: Comparing project performance before vs during Covid-19*

| | Project Performance Before Covid-19 | Project Performance During Covid-19 |
|---|---|---|
| **Finance/IT** | | |
| N | 134 | 134 |
| Mean | 5.4851 | 5.5970 |
| Std. Deviation | .95862 | .91075 |
| Range | 5.00 | 5.00 |
| **AEC** | | |
| N | 101 | 101 |
| Mean | 5.4678 | 5.3723 |
| Std. Deviation | .85708 | 1.01510 |
| Range | 4.60 | 4.60 |

Secondly, the relationship between communication frequency and performance in such high virtuality teams is dissimilar (Goris et al., 2000) to that of low virtuality teams.

We observed that in teams that spend less time working remotely on their projects, their highest performance levels are observed when they engage in moderately frequent communication (neither too much nor too little) while the lowest project team performance levels are observed when the teams engage in either too little or too much communication (Figure 3). This relationship was earlier confirmed by Patrashkova-Volzdoska et al. (2003), who argued that very high communication frequency increases information processing, leading to overloading the team's capabilities eventually hindering their performance, while in the same vein, low communication frequency limits the supply of information to team members and limits their performance.

*Figure 3: Moderation plot for Communication Frequency*



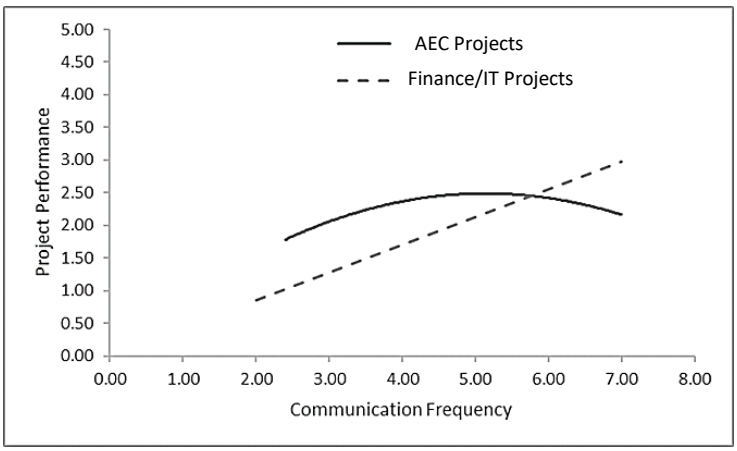
On the other hand, in teams that spend most of their time working remotely on projects—otherwise known as high virtuality teams, the pattern is quite different. This provides an interesting and unexpected insight into how such teams perform. As can be observed in the plot (figure 3), communication frequency does not seem to matter as much in high virtuality teams. As a matter of fact, virtuality moderates communication frequency and performance such that the inverted u relationship is preserved in low virtuality teams only. In high virtuality teams however, the curve is less pronounced across all levels of communication frequency, implying that the performance of such teams is less sensitive to the frequency of the communication within them.

In such teams, the project performance slowly diminishes as teams communicate more frequently as more information appears to overwhelm the team members. The difficulty of sifting through volumes of emails and attending too many meetings often lead to burnout and mental deflation for the teams. Gradually, as the frequency of communication continues to increase, there appears to be a slight but gradual increase in project performance which can be attributed to situations where the complexity and risk of the project increases. At this point, more information is required for clarification, mitigation of risks, informed decision making, and often, getting the project back on track. This is also true in that projects that appear to be off-track require more meetings, email conversations, phone calls and overall collaboration.

This dynamic can be attributed to the nature of these high virtuality projects. Kratzer (2001) confirmed this in his study, concluding that a low communication frequency in innovation teams—characterized by high virtuality—may lead to higher

performance, as such low frequency implies communication effectiveness within the team.

*Figure 4: AEC vs Finance/IT Projects Plots for Communication Frequency*




Construction and engineering projects are considered low virtuality projects as the project team needs to engage physically and in the same space during the project, which is why the relationship between communication frequency and project performance tends to follow the inverted-u shape (Figure 4). A post hoc extraction of only AEC project responses showed that this relationship was indeed inverted-u as can be observed from the curve in Figure 4. Since projects like these require a large number of people—or team members—who have to interact physically and execute the project activities within the same location, these teams tend to make use of all available communication channels to pass information around—both internally and externally—especially verbally.

In addition to this, the outcome of these types of projects are typically physical and tangible in nature, such as buildings, transportation systems, civil or engineering

structures etc. This is why Patrashkova-Volzdoska et al. (2003) observed a better relationship between communication frequency and project performance in face-to-face communication than in email or computer-mediated communication.

Conversely, in IT projects, our results revealed that the use of computer-mediated communication achieved higher efficiency as can be seen from the assessment of IT projects in Table 18 which showed a mean project performance of 5.597 (SD=0.911), compared to AEC projects that experienced a mean project performance 5.372 (SD=1.014). We argue that these team members do not necessarily have to see each other to collaborate, communicate or execute the project activities. These teams have also been observed to have the highest virtuality in the study and tend to communicate with each other using more technology and tools (virtuality mean = 0.8930; SD=0.204) compared to the less virtual, construction teams (virtuality mean = 0.7550; SD=0.273). An observation of responses from these F/IS teams showed that the communication frequency – performance relationship was linear (Figure 4), providing an implicit explanation for why the relationship curve in the full model (Figure 3) became flatter. There is therefore a tendency for these high virtuality project teams to easily share information with each other using the technology at their disposal.

## 5.2 Leadership Effectiveness – Project Performance

There was also significant support for hypothesis 3, confirming that in more virtual teams, poor leadership effectiveness tends to diminish project performance (Hoch and Kozlowski, 2012). The absence of physical interactions and engagement between the leader and the project team tends to diminish the performance of such teams over time.

We observed that IT projects (high virtuality projects) tend to have higher reported leadership effectiveness scores when compared to AEC projects (low virtuality projects) without the influence of virtuality as a moderator—as can be observed from the mean scores in Table 18. AEC projects had a mean leadership effectiveness score of 5.1337 (SD=1.0140), lower than for IT projects with mean score of 5.2575 (SD=1.0181). However, as the moderation plot in Figure 5 reveals, the differences in performance levels began to appear with various levels of virtuality even though these two industries exhibited similar slopes and relationships with performance without moderation in Figure 6.

The performance improvement in AEC projects (with low virtuality) was rapid with increasing levels of leadership effectiveness and exceeded the performance of IT projects that initially exhibited a relatively higher performance. This plot revealed that teams with lower virtuality had stronger performance improvements as the leadership effectiveness increased than teams with higher virtuality. This result is also a validation of the study by Baard et al. (2014) and Garro-Abarca et al. (2021) that found leadership to be a crucial factor for the successful performance of virtual teams especially with regards to adapting and responding to changes and challenges during their tasks.

*Figure 5: Moderation plot for Leadership Effectiveness*

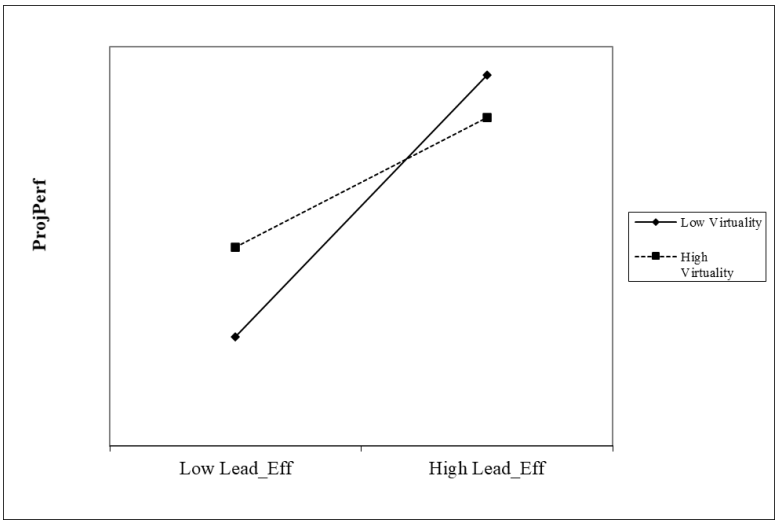
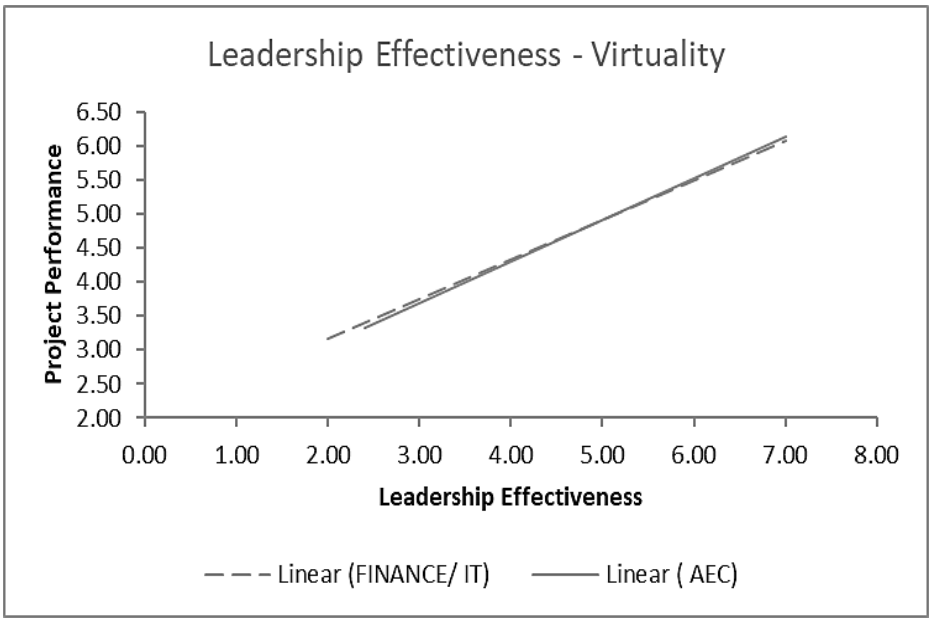



*Figure 6: Leadership Effectiveness – Project Performance plots without the moderator*




Both AEC and IT projects were observed to exhibit similar leadership effectiveness-performance relationship without the moderating effect of virtuality (Figure 6). This goes to show that this trend cuts across these two business areas—the higher the effectiveness of the leader, the better the project team performs. Conversely, with the moderation of virtuality, differences between these two business

areas begin to emerge. Also, there exists an intersection in the plot when comparing both high virtuality and low virtuality teams, implying an optimal point where both types of teams have the same level of project performance.

Physical presence can help a leader improve the communication, collaboration and cohesion within the team; the effectiveness of the project leader is dampened by the physical distance effected by high virtuality. Some of the responsibilities of the project leader includes coordinating the team, providing leadership for every facet of the project, meeting clients' expectations for the project and actively involves the project team to gain their commitments. All of these responsibilities are encumbered by the leader's physical distance from the team, or the projects being executed. Team motivation and supervision, which are critical responsibilities of the project leader, may not be as effective in higher virtuality teams as it would in a more face-to-face or low virtuality teams (Reyes, Luna & Salas, 2021).

A possible explanation of the diminished performance levels in high virtuality teams that have a highly efficient leaders could be this: leaders who are not competent in using the technological tools afforded by high virtuality will be unable to effectively lead such virtual teams, resulting in even poorer project performance across board. As revealed in Iorio and Taylor's (2014) study, training plays a vital role in equipping the team leader to better engage the team. Their study suggested that in high virtuality teams, prior experience in the usage of the technological medium adopted in the project team reinforces the effectiveness of the leader in fostering project team performance.

Leadership cannot be effective without proper and adequate communication within the team and the leader's possession of effective communication skills enable the creation and clear expression of the project's aims and objectives (Balthazard, Waldman, & Warren, 2009). Figure 7 in Appendix C provides a combined graphical illustration of the relationships of both communication frequency and leadership effectiveness on project performance.

## 5.3. Contributions

The Covid-19 pandemic has altered the way projects and organizations as a whole work and can be typified using the burning platform analogy (Cawby, 2021). Project teams have had to adapt to new patterns of communication and collaboration, and leaders have also been pushed to new frontiers of management approach. Since this study was conducted at a point where virtual work was in its maturity, and where return to co-located workspaces was being implemented in phases, the results of our research will prove helpful to both practitioners and academics.

This study extends the literature on virtuality, communication frequency, leadership effectiveness and project team performance in several ways.

Firstly, this study focused on teams that were involved in project activities during the Covid-19 era and sheds more insight into how such projects and teams performed during the pandemic as well as the level of effectiveness the project leaders exhibited in the VUCA world (Volatility, Uncertainty, Complexity and Ambiguity) (Baran & Woznyj, 2021)

Secondly, we took a different approach to measuring virtuality as recommended by Schweitzer & Duxbury (2010) by operationalizing it as a proportion of time spent working remotely on the project. This provided us with a virtuality score that was applied to individual responses and captured the extent to which such teams were considered virtual. Other conceptualizations of virtuality exist in literature, however, we found none that empirically measured virtuality with this approach.

Thirdly, we were able to divide the projects into two distinct business areas, i.e., AEC projects and IT/Finance projects which were found to be fundamentally different in their approaches to managing projects and provided interesting insights into how these two types of teams performed.

Practical implications from this study are seen from several angles. Highly virtual teams are more likely to experience poorer project team performance than low virtuality teams when the leader is highly effective in managing the team. This is because as much as virtuality tries to replicate physical collaboration as much as possible, it cannot be a substitute for it. The lack of media richness afforded by face-to-face collaboration and leadership will always be evident in the performance of high virtuality teams.

Project leaders, supervisors and coordinators should be aware of this phenomenon especially as organizations are slowly returning to a more hybrid workspace. Knowing that a one-size-fits-all approach for managing post-Covid project teams is counterproductive, this will enable them to adopt the most suitable leadership

styles as well as communication modes that will improve the odds of project success in such teams.

In addition, the leadership effectiveness-performance relationship exhibits an interesting phenomenon, as there appears to be an optimal point in this relationship when comparing high and low virtuality teams. This occurrence also confirms that a more effective project leader tends to influence the project performance whether the team is highly virtual or not. Leaders can expect a high performance in their project teams regardless of the level of virtuality when they focus on empowering and supporting the team as reflected in the survey responses.

Furthermore, project managers need to understand that the patterns of communication—in this case, communication frequency—exhibited by high virtuality teams have significantly different impacts on performance than those exhibited by low virtuality teams. Understanding the nuances in these relationships will help the team, as well as the team champion maximize the rate and frequency of information exchange within the team to achieve acceptable levels of performance.

AEC project managers need to be more conscious of over-communication within the project teams as performance has been found to be very sensitive to communication frequency. In the same vein, IT and Finance-related projects need to exploit the use of technology in collaborating to optimize their project performance. The benefits of high virtuality on the communication frequency-performance relationship put such high virtuality teams at an advantage over low virtuality teams, as the former have built

efficiencies in technology usage and have found better ways to adapt the technologies to suit their project work (as posited by the Adaptive Structuration Theory).

Finally, our results are consistent with findings from prior studies. The importance of leadership effectiveness on project performance cannot be overemphasized. Eisenberg et al. (2019) suggested that leaders combine different approaches to leadership effectiveness with other styles of management that could improve team communication and lead to better project performance as a one-size-fits-all leadership approach may be detrimental to project performance. In the same vein, we observed that the two project types used in this study had distinct communication frequency—performance relationships which project leaders and managers need to be aware of. The frequency of communication within project teams therefore needs to be carefully considered as observed from our study, as its effects on performance varies with the type of projects being executed.

### 5.4 Limitations and Areas for Future Research

Despite having several limitations, the results of this study have laid the foundation for further research into virtual teams, leadership, communication, and performance in project teams.

This study has confirmed previous research into the area of communication frequency, leadership effectiveness and project performance, however there are several suggestions for future studies.

Although this study was conducted on team members who have worked on AEC (Architecture, Engineering and Construction) and Finance / IT-related projects

collectively since the Covid pandemic, we however recommend studying the effects of virtuality on these industries independently and assessing the nature of the relationships. Even though we controlled for the project business area in our study, we do not dive into detailed differences in these industries or analyze them separately. Instead, we separated these industries and observed the responses gathered from the participants. We were able to note the similarities and differences between these industries by observing their descriptive statistics.

Furthermore, we adopted a cross-sectional approach to this study with the use of online questionnaires for gathering responses. With this method, we were unable to test the causal relationships in the model and we recommend future research using longitudinal methods to assess project performance over time using the same predictors. Moreover, we treated virtuality as a moderator in our model, with communication frequency and leadership effectiveness as predictors of project performance. Future studies could assess virtuality as a predictor of performance, with communication frequency acting as a moderator of the relationship. This would provide an alternative assessment of the relationship existing within these constructs.

Another area of future research is in the area of virtuality which we captured using the proportion of remote work done during the project relative to the total time spent on the project. This measurement approach to virtuality is one of three approaches proposed by Schweitzer & Duxbury (2010) for measuring virtuality. We therefore recommend that subsequent studies adopt the other approaches to measuring virtuality under similar conditions to identify whether the results are similar across board. Finally, we focused purely on transformational leadership style for managing

project teams. We recommend that future studies explore the several other styles of leadership to understand how they influence project performance at varying levels of virtuality.

Finally, communication frequency is only one of the several elements of communication and researchers might consider studying the moderating effects of virtuality on the other facets such as communication quality, content, timeliness and also closed-loop communication. These areas will provide interesting new insights into how communication influences the performance of project teams.

## 5.5 Conclusion

Managing a project effectively is a complex and multifaceted process that requires optimizing every facet of the project and ensuring that all activities are geared towards meeting the sponsor's requirements and expectations. Among other things, it involves communicating effectively and efficiently with all stakeholders, as well as leading the team members to achieve the project goals and objectives. While numerous guidelines exist for managing projects, the one key characteristic of projects across all industries is change, and good project managers should not remain stoic or rigid in their approach to managing the project, rather, they should be able to adapt their practices—including communication and leadership processes--to changes when they arise.

The emergence of virtual project work due to the pandemic has provided a case-in-point for changes that may arise during a project. The frequency of communication within the team should be balanced in a way that the benefits both the project

activities and the team. Too frequent meetings, calls and formal interactions have different implications on performance under certain project conditions, especially virtuality, and the project leader needs to assess these conditions before making decisions. In the same vein, there is no one-size-fits-all approach to leadership especially when changes arise during the project. Virtuality demands a different approach to leadership from the project manager, and it is expected that they exhibit the flexibility required to manage teams with varying proportions of virtuality.

## Appendix A: Definition of Terms

| | |
|---|---|
| **Communication** | The process of sharing information, especially when it increases understanding between people or groups |
| **Performance** | The measure of the achievement of objectives based on generally accepted and predetermined metrics such as scope, schedule, and budget for projects. |
| **Project** | A temporary and unique endeavor to achieve a specific result or outcome and typically includes a series of interrelated activities executed over a pre-determined period of time and within the constraints of scope, quality, cost and schedule. |
| **Project Team** | A group of individuals with different roles within the project who perform or execute the project task under the leadership of a Project Manager who ensures that the project objectives are met. These project team members support the project manager by coordinating their individual efforts to accomplish the project task. |
| **Virtual Team** | A group of individuals who work together remotely and rely on communication technology in order to collaborate. The term can also refer to groups or teams that work together asynchronously or across organizational levels. (Also known as a geographically dispersed team, distributed team or remote team). |
| **Virtual Project Teams** | A virtual team that does a project. (These teams tend to disband after the project objectives have been met.) |
| **Virtuality** | The proportion of the time spent on a project that team members work virtually or remotely. |

## Appendix B: Measurement Items

**Scale Items used in the survey.**

**Communication Frequency**

Based on the project described above, how frequently did you: -

ComFreq1-- Send project related emails to project team members?

ComFreq2-- Receive project related emails from your project team members?

ComFreq3-- Engage in physical (in-person) discussions with project team member(s) either formally or informally?

ComFreq4-- Call your project team members using virtual collaboration software on project related issues?

ComFreq5-- Receive calls from your project team members regarding the project?

ComFreq6-- Attend project meetings physically in the office?

ComFreq7-- Meet using virtual collaboration software such as Zoom, MS Teams etc?

**Project Performance**

Please indicate the level to which you agree or disagree with the following statements as they relate to the performance of the project you described above during Covid. This project team:

ProjPerf1 – Has been effective in reaching its goals

ProjPerf2 - Generally meets its project objectives

ProjPerf3-- Is generally on time when it completes its work

ProjPerf4-- Generally completes its work within budget

ProjPerf5-- Has not been effective in reaching its goals

**Leadership Effectiveness**

Please indicate the level to which you agree or disagree with the following statements as they relate to the effectiveness of the Project Leader of the project described above.

LeadEff1-- The Project Leader offered new ideas or approaches to do our jobs better

LeadEff2 – The team members felt that the Project Leader was not helpful and supportive

LeadEff3 – The Project Leader made sure that the team members had clear goals to achieve

LeadEff4-- The Project Leader kept individuals working together as a team

**Virtuality**

Tot_WrkHrs-- How many total hours in a week did you spend working on activities related to the project?

Rem_WrkHrs-- Of the number of hours in the above question, how many hours in a week did you spend working virtually (remotely or from home) on the project?

## Appendix C: Sample Classifications

*Table 20: Age classification by industry/project type*

| AEC Projects | Frequency | Percent | Cumulative Percent |
|---|---|---|---|
| Below 25 | 8 | 7.9 | 7.9 |
| 25-- 29 | 24 | 23.8 | 31.7 |
| 30-- 39 | 39 | 38.6 | 70.3 |
| 40-- 49 | 19 | 18.8 | 89.1 |
| 50 years and above | 11 | 10.9 | 100.0 |
| Total | 101 | 100.0 | |
| **Finance / IT Projects** | **Frequency** | **Percent** | **Cumulative Percent** |
| Below 25 | 10 | 7.5 | 7.5 |
| 25-- 29 | 40 | 29.9 | 37.3 |
| 30-- 39 | 48 | 35.8 | 73.1 |
| 40-- 49 | 23 | 17.2 | 90.3 |
| 50 years and above | 13 | 9.7 | 100.0 |
| Total | 134 | 100.0 | |

*Table 21: Education classification by industry/project type*

| AEC Projects | Frequency | Percent | Cumulative Percent |
|---|---|---|---|
| High School | 22 | 21.8 | 21.8 |
| Undergraduate Degree (Bachelors) | 44 | 43.6 | 65.3 |
| Graduate degree (Masters) | 27 | 26.7 | 92.1 |
| Post Graduate degree (Doctorate) | 5 | 5.0 | 97.0 |
| Other | 3 | 3.0 | 100.0 |
| Total | 101 | 100.0 | |
| **Finance / IT Projects** | **Frequency** | **Percent** | **Cumulative Percent** |
| High School | 7 | 5.2 | 5.2 |
| Undergraduate Degree (Bachelors) | 83 | 61.9 | 67.2 |
| Graduate degree (Masters) | 32 | 23.9 | 91.0 |
| Post Graduate degree (Doctorate) | 12 | 9.0 | 100.0 |
| Total | 134 | 100.0 | |

*Table 22: Project value classification by industry/project type*

| AEC Projects | Frequency | Percent | Cumulative Percent |
|---|---|---|---|
| Less than $50,000 | 9 | 8.9 | 8.9 |
| $50,000 - $250,000 | 34 | 33.7 | 42.6 |
| More than $250,000 | 58 | 57.4 | 100.0 |
| Total | 101 | 100.0 | |
| **Finance / IT Projects** | **Frequency** | **Percent** | **Cumulative Percent** |
| Less than $50,000 | 29 | 21.6 | 21.6 |
| $50,000 - $250,000 | 49 | 36.6 | 58.2 |
| More than $250,000 | 56 | 41.8 | 100.0 |
| Total | 134 | 100.0 | |

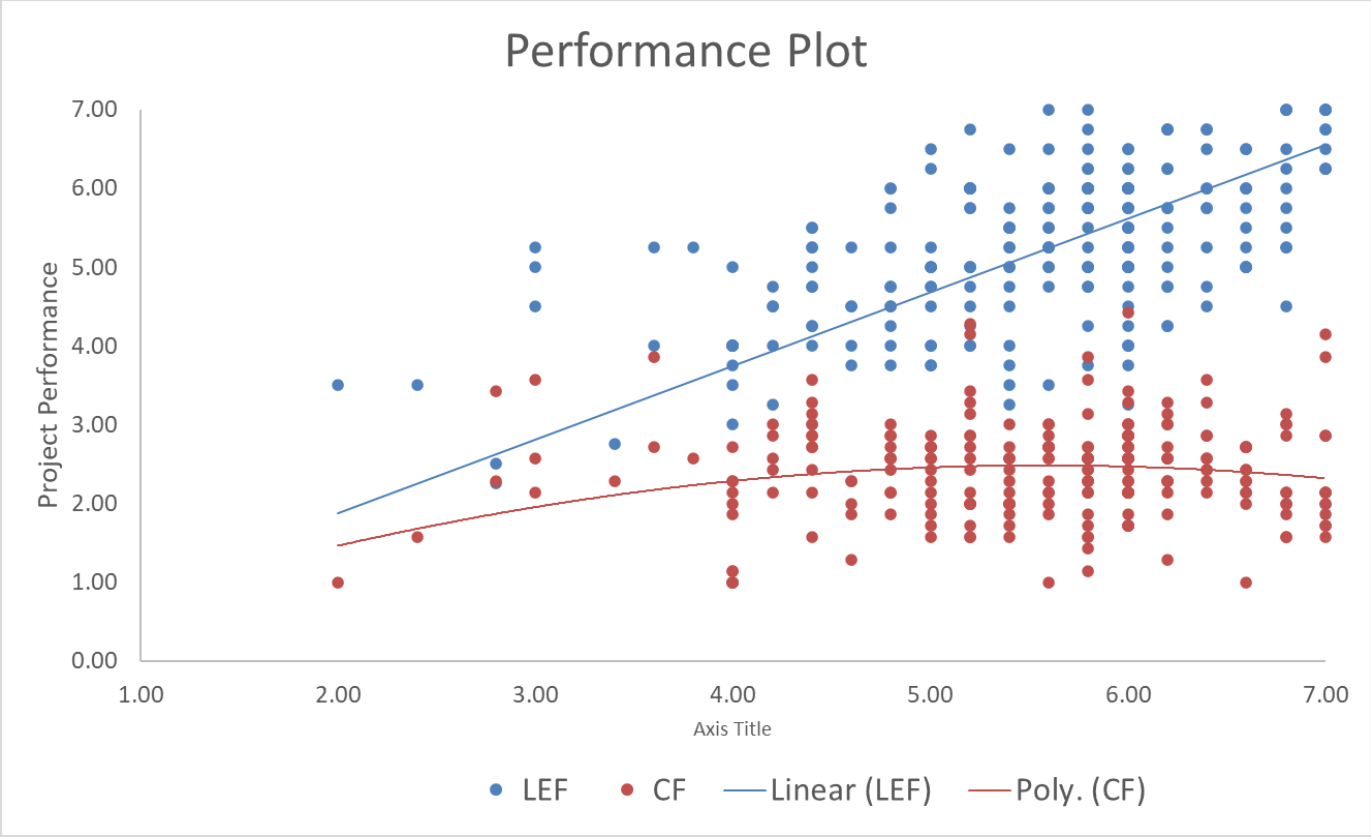
*Table 23: Project location classification by industry/project type*

| AEC Projects | Frequency | Percent | Cumulative Percent |
|---|---|---|---|
| In one or more locations in only one city | 36 | 35.6 | 35.6 |
| In several cities in one province | 25 | 24.8 | 60.4 |
| in several provinces in one country | 35 | 34.7 | 95.0 |
| in several countries | 5 | 5.0 | 100.0 |
| Total | 101 | 100.0 | |
| **Finance / IT Projects** | **Frequency** | **Percent** | **Cumulative Percent** |
| In one or more locations in only one city | 57 | 42.5 | 42.5 |
| In several cities in one province | 22 | 16.4 | 59.0 |
| in several provinces in one country | 26 | 19.4 | 78.4 |
| in several countries | 29 | 21.6 | 100.0 |
| Total | 134 | 100.0 | |

*Table 24: Project duration classification by industry/project type*

| AEC Projects | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| | Up to 3 months | 11 | 10.9 | 10.9 | 10.9 |
| | 3 – 6 months | 26 | 25.7 | 25.7 | 36.6 |
| | 6 – 24 months | 43 | 42.6 | 42.6 | 79.2 |
| | More than 24 months | 21 | 20.8 | 20.8 | 100.0 |
| | Total | 101 | 100.0 | 100.0 | |
| Finance / IT Projects | | Frequency | Percent | Valid Percent | Cumulative Percent |
| | Up to 3 months | 35 | 26.1 | 26.1 | 26.1 |
| | 3 – 6 months | 51 | 38.1 | 38.1 | 64.2 |
| | 6 – 24 months | 43 | 32.1 | 32.1 | 96.3 |
| | More than 24 months | 5 | 3.7 | 3.7 | 100.0 |
| | Total | 134 | 100.0 | 100.0 | |

*Figure 7: Relationships of Communication Frequency & Leadership Effectiveness on Project Performance.*



## References:


Adams, S. K. (2007). Disciplinary hetero and homogenous design team convergence. Blacksburg, VA: Virginia Polytechnic Institute and State University.

Ahola, T., 2018. So alike yet so different: a typology of interorganizational projects. *Int. J. Proj. Manag.* 36, 1007–1018.

Ahuja, M., & Galvin, J. (2003). Socialization in virtual groups. *Journal of Management*, 29(2), 161–185. https://doi.org/10.1177/014920630302900203

Aiken, L. S., & West, S. G. (1991). Testing and interpreting interactions in multiple regression. Sage Publications.

Allen, T. D., Golden, T. D., & Shockley, K. M. (2015). How effective is telecommuting? Assessing the status of our scientific findings. Psychol. *Sci.Public Interest* 16, 40–68. doi: 10.1177/1529100615593273

Anantatmula, V., & Thomas, M. (2010). Managing global projects: A structured approach for better performance. *Project Management Journal,* 41(2), 60–72.

Andressen, P., Konradt, U., & Neck, C. P. (2012). The relation between self-leadership and transformational leadership: Competing models and the moderating role of virtuality. *Journal of Leadership & Organizational Studies*, 19: 68-82.

Aritz, J., Walker, R., & Cardon, P. W. (2018). Media use in virtual teams of varying levels of coordination. *Business and Professional Communication Quarterly,* 81(2), 222–243. https://doi.org/10.1177/2329490617723114

Arnison, L., & Miller, P., (2002). Virtual teams: a virtue for the conventional team. *Journal of Workplace Learning,* 14 (4), 166–173.

Aubert, B. A., & Kelsey, B. L. (2003). Further understanding of trust and performance in virtual teams. *Small Group Research*, 34: 575–618.

Baker, G. (2002). The effects of synchronous collaborative technologies on decision making: A study of virtual teams. *Information Resources Management Journal,* 15: 79–93.

Balthazard, P. A., Waldman, D. A., & Warren, J. E. (2009). Predictors of the emergence of transformational leadership in virtual decision teams. *The Leadership Quarterly*, 20: 651-663.

Balthazard, P., Potter, R. & Warren, J., (2004), 'Expertise, extraversion and group interaction styles as performance indicators in virtual teams', *The DATABASE for Advances in Information Systems* 35(1), 41–64.

Baran, B. E., & Woznyj, H. M. (2021). Managing VUCA: The human dynamics of agility. *Organizational Dynamics*, *50*(2), 100787. https://doi.org/10.1016/j.orgdyn.2020.100787

Bass, B.M. (1985). *Leadership and performance beyond expectations*. Free Press, New York

Bass, B.M., & Avolio, B.J. (1994), Improving Organizational Effectiveness Through

Bell, B. S., & Kozlowski, S. W. J. (2002). A typology of virtual teams. *Group & Organization Management*, 27: 14–49.

Bhat, S. K., Pande, N., & Ahuja, V. (2017). Virtual team effectiveness: an empirical study using SEM. *Procedia Computer Science*, 122, 33–41. https://doi.org/10.1016/j.procs.2017.11.338

Boland, B., De Smet, A., Palter, R., & Sanghvi, A. (2020). Reimagining the office and work life after COVID-19. McKinsey & Company.

Bollen, K., & Lennox, R. (1991). Conventional wisdom on measurement: a structural equation perspective. *Psychological Bulletin*,110:2, 305-314.

Bourgault, M., Drouin, N., & Hamel, É. (2008). Decision making within distributed project teams: An exploration of formalization and autonomy as determinants of success. *Project Management Journal*, 39, S97–S110.

Bryant, S.M., Albring, S.M. & Murthy, U., (2009). The effects of reward structure, media richness and gender on virtual teams. *International Journal of Accounting Information Systems* 10 (4), 190–213.

Bui, H., Chau, V. S., Degl'Innocenti, M., Leone, L., & Vicentini, F. (2019). The resilient organization: A meta-analysis of the effect of communication on team diversity and team performance. *Applied Psychology*, 68(4), 621–657. https://doi.org/10.1111/apps.12203

Burgoon, J. K., Bonito, J. A., Ramirez, A., Jr., Dunbar, N. E., Kam, K., & Fischer, J. (2002). Testing the interactivity principle: Effects of mediation, propinquity, and verbal and nonverbal modalities in interpersonal interaction. *Journal of Communication*, 52: 657–677.

Campion, M., Papper, E. & Medsker, G. (1996). Relations between work team characteristics and effectiveness: a replication and extension, *Personnel Psychology,* 49 (2), , pp. 429–452.

Carte, T., Chidambaram, L., & Becker, A. (2006). Emergent leadership in self-managed virtual teams. *Group Decision and Negotiation,* 15: 323-343.

Cawby M. (2021). The velocity of crisis: How the pandemic creates opportunities for change. *Journal - American Water Works Association, 113*(2), 80–81. https://doi.org/10.1002/awwa.1675

Charlier, S. D., Stewart, G. L., Greco, L. M., & Reeves, C. J. (2016). Emergent leadership in virtual teams: A multilevel investigation of individual communication and team dispersion antecedents. *The Leadership Quarterly,* 27(5), 745–764. https://doi.org/10.1016/j.leaqua.2016.05.002

Chidambaram, L. (1996). Relational development in computer-supported groups, *MIS Quarterly* 20 (2) 143–165.

Chin, W., & Newsted, P. (1999). Structural equation modeling analysis with small samples using partial least squares. *Stat. Strategies Small Sample Res.* 1, 307–341.

Choi, O.-K., & Cho, E. (2019). The mechanism of trust affecting collaboration in virtual teams and the moderating roles of the culture of autonomy and task complexity. *Computers in Human Behavior,* 91, 305–315. https://doi.org/10.1016/j.chb.2018.09.032

Chudoba, K. M., Wynn, E., Lu, M., & Watson-Manheim, M. B. (2005). How virtual are we? Measuring virtuality and understanding its impact in a global organization. *Information Systems Journal,* 15: 279-306.

Cohen, S. G., & Gibson, C. B. (2003). In the beginning: Introduction and framework. In S. G. Cohen & C. B.Gibson (Eds.), Virtual teams that work: Creating conditions for virtual team effectiveness: 1-13. San Francisco: Jossey-Bass.

Cohen, S.G., & Bailey, D.E., (1997). What makes teams work: group effectiveness research from the shop floor to the executive suite. *Journal of Management* 23 (3), 239–290.

Cooprider, J.G., & Henderson, J.C. (1991). Technology-process fit: Perspectives on achieving prototyping effectiveness. *Journal of Management Information Systems,* 7, 3, 67–87.

Cramton, C. D. (2002). Finding common ground in dispersed collaboration. *Organizational Dynamics,* 30: 356–367.

Cramton, C.D. (2001). The mutual knowledge problem and its consequences for dispersed collaboration. *Organization Science,* 12, 3, 346–371.

Cui, T., Wu, Y., & Tong, Y. (2018). Exploring ideation and implementation openness in open innovation projects: IT-enabled absorptive capacity perspective. *Information & Management,* 55(5), 576–587

Cummings, J., Espinosa, J.A., & Pickering, C. (2009). Crossing spatial and temporal boundaries in globally distributed projects: A relational model of coordination delay. *Information Systems Research,* 20, 3 , 420–439.

Curlee, W. (2008). Modern virtual project management: The effects of a centralized and decentralized project management office. *Project Management Journal*, 39, Supplement S83–S96.

DeChurch, L. A., & Mesmer-Magnus, J. R. (2010). The cognitive underpinnings of effective teamwork: A meta-analysis. *The Journal of Applied Psychology, 95*(1), 32–53. https://doi.org/10.1037/a0017328

deGuinea, A. O., Webster, J., & Staples, D.S. (2012). A meta-analysis of the consequences of virtualness on team functioning. *Information & Management*, 49: 301-308.

DeLone, W.H., & McLean, E.R. (2003). The DeLone and McLean model of information systems success: A ten-year update. *Journal of Management Information Systems,* 19, 4, 9–30.

Denison, D. R., Hooijberg, R., Quinn, R. (1995) Paradox and performance: Toward a theory of behavioral complexity in managerial leadership. *Organizational Science* 6(4) 524-540

Dennis, A.R., Fuller, R.M., Valacich, J.S. (2008) Media, tasks, and communication processes: a theory of media synchronicity. *MIS Q* 32(3):575–600

DeRosa, D. , Hantula, D., Kock, N., & D'Arcy, J. (2004). Trust and leadership in virtual teamwork: A media naturalness perspective. *Human Resource Management,* 43(2–3), 219–232. https://doi.org/10.1002/hrm.20016

Deru, M., & Torcellini, P. (2005) Performance metrics research project. Technical report NREL/TP-550-38700, National Renewable Energy Lab, Golden, CO.

DeSanctis, G., & Poole, M. (1994). Capturing the complexity in advanced technology use: adaptive structuration theory. *Organization Science*, 5(2), 121-147

Diamantopoulos, A., & Winklhofer, H.M., (2001) Index construction with formative indicators: An alternative to scale development. *Journal of Marketing Research*, 38, 259-277.

Dionne, S. D., Yammarino, F. J., Atwater, L. E., & Spangler, W. D. (2004). Transformational leadership and team performance. *Journal of Organizational Change Management,* 17(2), 177–193. https://doi.org/10.1108/09534810410530601

Dube, S. & Marnewick, C., (2012). The constituents of virtual project teams, Project Management South Africa (PMSA) Biennial National Conference 2012, PMSA, Johannesburg.

Edmondson, A. (1999). Psychological safety and learning behavior in work teams. *Administrative Science Quarterly*, 44, 350. doi:10.2307/2666999

Edwards, J. R., & Bagozzi, R. P. (2000). On the nature and direction of relationships between constructs. *Psychological Methods* 5(2), 155-174.

Eisenberg, J., Post, C., & DiTomaso, N. (2019). Team dispersion and performance: The role of team communication and transformational leadership. *Small Group Research,* 50(3), 348–380. https://doi.org/10.1177/1046496419827376

El-Tayeh, A., Gil, N., & Freeman, J., (2008) A methodology to evaluate the usability of digital socialization in ‘‘virtual’’ engineering design, *Research in Engineering Design,* 19, 29–45. http://dx.doi.org/10.1007/s00163-007-0037-7

Espevik, R., Johnsen, B. H., Eid, J., & Thayer, J. F. (2006). Shared mental models and operational effectiveness: Effects on performance and team processes in submarine attack teams. *Military Psychology*, 18, 23–36.

Eurofound (2021). Living, working and COVID-19 (Update April 2021): Mental health and trust decline across EU as pandemic enters another year, Publications Office of the European Union,Luxembourg.
https://www.eurofound.europa.eu/sites/default/files/ef_publication/field_ef_document/ef21064en.pdf

Field, A., (2009). *Discovering Statistics Using SPSS* (3rd ed.) SAGE Publications, London.

Fjermestad, J. (2004). An analysis of communication mode in group support systems research. *Decis Support Syst*, 37(2):239–263

Fornell, C., & Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. *J. Mark. Res.* 18, 39–50. doi: 10.2307/3151312

Gaan, N. (2012). Collaborative tools and virtual team effectiveness: An inductively derived approach in India’s software sector. *Decision*, 39(1), 5–27.

Galegher, J. & Kraut, R.E. (1994). Computer-mediated communication for intellectual teamwork: an experiment in group writing. *Information System Research,* 5 (2) 110–138.

Ganesh, M. P., & Gupta, M. (2010). Impact of virtualness and task interdependence on extra-role performance in software development teams. *Team Performance Management,* 16: 169-186.

Garro-Abarca, V., Palos-Sanchez, P., & Aguayo-Camacho, M. (2021). Virtual teams in times of pandemic: Factors that influence performance. *Front. Psychol.* 12:624637. doi: 10.3389/fpsyg.2021.624637

Gibson, C. B., & Gibbs, J. L. (2006). Unpacking the concept of virtuality: The effects of geographic dispersion, electronic dependence, dynamic structure, and national diversity on team innovation. *Administrative Science Quarterly*, 51: 451-495.

Gibson, C.B., Huang, L., Kirkman, B.L., & Shapiro, D.L., (2014). Where global and virtual meet: The value of examining the intersection of these elements in twenty-first century teams. *Ann. Rev. Org. Psychol. Org. Behav.,* 1 (1), 217–244.

Giddens, A. (1979). *Central Problems in Social Theory*, Berkeley, CA: University of California Press.

Glikson, E., & Erez, M. (2020). The emergence of a communication climate in global virtual teams. *Journal of World Business,* 55(6), 101001. https://doi.org/10.1016/j.jwb.2019.101001

Goh, S., & Wasko, M. (2012). The effects of leader-member exchange on member performance in virtual world teams. *Journal of the Association for Information Systems,* 13: 861-885.

González-Navarro, P., Orengo, V., Zornoza, A., Ripoll, P., & Peiró, J. M. (2010). Group interaction styles in a virtual context: The effects on group outcomes. *Computers in Human Behavior,* 26: 1472-1480.

González-Romá, V., & Hernández, A. (2014). Climate uniformity: Its influence on team communication quality, task conflict, and team performance. *Journal of Applied Psychology*, 99(6), 1042–1058.

Gordon, R.L., & Curlee, W. (2011). *The virtual project management office: Best practice, proven methods*. Management Concepts Inc., Vienna, VA.

Goris, J. R., Vaught, B. C., & Pettit Jr., J. D. (2000). Effects of communication direction on job performance and satisfaction: A moderated regression analysis. J. *Bus. Commun.*, 37(4), 348–369.

Green, S.G. & Taber, T.D. (1980). The effects of three social decision schemes on decision group process. *Organizational Behaviour and Human Performance,* 25, 97–106.

Griffith, T. L., & Neale, M. A. (2001). Information processing in traditional, hybrid, and virtual teams: From nascent knowledge to transactive memory. *Research in Organizational Behavior*, 23, 379–421.

Griffith, T., Sawyer, J., & Neale, M. (2003). Virtualness and knowledge in teams: managing the love triangle of organizations, individuals, and information technology. *MIS Quarterly,* 27(2), 265-287. doi:10.2307/30036531

Guzzo, R. A., & Dickson, M. W. (1996). Teams in organizations: Recent research on performance and effectiveness. *Annual Reviews of Psychology,* 47, 307–338.

Hackman, J. R. (2002). *Leading teams: Setting the stage for great performances*. Boston, MA: Harvard Business School Press.

Hackman, J. R., & Morris, C. G. (1975). Group tasks, group interaction process, and group performance effectiveness: A review and proposed integration. In L. Berkowitz (Ed.), *Advances in experimental social psychology*, 8, 45–99.

Hackman, J., (1990). *Groups that work (and those that do not): Creating conditions for effective teamwork*. Jossey-Bass, San Francisco, CA.

Hackman, J., Walton, R., (1986). Leading groups in organizations. P.S Goodman, ed. *Designing Effective Work Groups*. Jossey-Bass, San Francisco.

Hair Jr, J. F., Anderson, R. E., Tatham, R. L., & Black, W. C. (1995). *Multivariate Data Analysis (*4th ed.) (Orkowsky, D., ed.). Prentice Hall, Englewood Cliffs, NJ.

Hair, J. F., Ringle, C. M., & Sarstedt, M. (2011). PLS-SEM: Indeed a silver bullet. *J. Mark. Theory Pract*. 19, 139–152. doi: 10.2753/mtp1069-667919 0202

Hair, J. F., Ringle, C. M., & Sarstedt, M. (2013). Partial least squares structural equation modeling: Rigorous applications, better results and higher acceptance. *Long Range Plan*. 46, 1–12. doi: 10.1016/j.lrp.2013.01.001

Han, H. J., Hiltz, S. R., Fjermestad, J., & Wang, Y. Q. (2011). Does medium matter? A comparison of initial meeting modes for virtual teams. *IEEE Transactions on Professional Communication,* 54: 376-391.

Harell, G., & Daim, T., (2009). Virtual IT teams and the importance of building trust. *IEEE IT Professional,* 48–51.

Harvey, M., Novicevic, M.M. & Garrison, G., (2004). Challenges to staffing global virtual teams. *Human Resource Management Review*,14 (3): 275–294.

Henderson, L. S. (2008). The impact of project managers' communication competencies: Validation and extension of a research model for virtuality, satisfaction, and productivity on project teams. *Project Management Journal*, 39, 48-59.

Herath, T., Herath, H. S. (2020). Coping with the new normal imposed by the COVID-19 pandemic: Lessons for technology management and governance. Information Systems Management,37(4), 277–283. https://doi-org.proxy.library.brocku.ca/10.1080/10580530.2020.1818902

Hertel, G., Geister, S., & Konradt, U. (2005). Managing virtual teams: A review of current empirical research. *Human Resource Management Review*, 15, 69-95.

Hinds, P., & Mortensen, M. (2005). Understanding conflict in geographically distributed teams: The moderating effects of shared identity, shared context, and spontaneous communication. *Organization Science,* 16(3), 290–307.

Hinds, P.J., & Bailey, D.E. (2003). Out of sight, out of synch: Understanding conflict in distributed teams. *Organization Science,* 14(6), 615–632.

Hoch, J. E., & Kozlowski, S. W. J. (2012). Leading virtual teams: Hierarchical leadership, structural supports, and shared team leadership. *Journal of Applied Psychology*, 99: 390-403.

Hollingshead, A. B., McGrath, J. E., & O'Connor, K.M. (1993). Group task performance and communication technology: A longitudinal study of computer-mediated versus face-to-face work groups. *Small Group Research,* 24: 307–333.

Hossein, G. (2012). A literature review on challenges of virtual team's leadership. *Journal of Sociological Research,* 3(2), 134-145.

Huang,W.W., Wei, K. K., Watson, R. T., & Tan, B. C. Y. (2002). Supporting virtual team-building with a GSS: An empirical investigation. *Decision Support Systems,* 34: 359–367.

Idrus, A., Sodangi, M. & Husin, M.H. (2011). Prioritizing project performance criteria within client perspective. *Research Journal of Applied Sciences,* 3(10), 1142–1151.

Iorio, J., & Taylor, J. E. (2015). Precursors to engaged leaders in virtual project teams. *International Journal of Project Management,* 33(2), 395–405. https://doi.org/10.1016/j.ijproman.2014.06.007

Iorio, J., Taylor, J.E., & Dossick, C.S. (2012). A bridge too far: examining the impact of facilitators on information transfer in global virtual project networks. *Eng. Proj. Org. J.* 2 (4), 188–201.

Jarvenpaa, S., & Leidner, D. (1999). Communication and trust in global virtual teams. *Organization Science,* 10(6), 791–865

Jarvis, C. B., MacKenzie, S. B., & Podsakoff, P. M. (2003). A critical review of construct indicators and measurement model misspecification in marketing and consumer research. *Journal of Consumer Research*, 30(2), 199–218. https://doi.org/10.1086/376806

Jarvis, C. B., MacKenzie, S. B., & Podsakoff, P. M. (2003). A critical review of construct indicators and measurement model misspecification in marketing and consumer research. *Journal of Consumer Research*, 30(2), 199–218. https:// doi.org/10.1086/376806

Johnson, S. D., Suriya, C., Yoon, S.W., Berrett, J. V., & La Fleur, J. (2002). Team development and group processes of virtual learning teams. *Computers and Education,* 39: 379–393.

Joshi, A., Lazarova, M. B., & Liao, H. (2009). Getting everyone on board: The role of inspirational leadership in geographically dispersed teams. *Organization Science,* 20, 240-252.

Jugdev, K., & Muller, R. (2005). A retrospective look at our evolving understanding of project success. *Project Management Journal,* 36(4), 19–31.

Kanawattanachai, P., & Yoo, Y. (2002). Dynamic nature of trust in virtual teams. *Journal of Strategic Information Systems,* 11: 187–213.

Kanawattanachai, P., & Yoo, Y. (2008). The impact of knowledge coordination on virtual team performance over time. *MIS Quarterly, 31*(4), 783–808.

Kankanhalli, A., Tan, B. C. Y., & Wei, K. K. (2007). Managing conflict in global virtual teams. *Journal of Management Information Systems,* 24(3), 237–274

Kayworth, T., & Leidner, D. (2000). The global virtual manager: A prescription for success. *European Management Journal,* 18: 183–194.

Keyton, J. (1997). Coding communication in decision making groups: Managing group life. *Communication in Decision Making Groups,* 236–269.

Keyton, J. (1999). *Relational communication in groups. The handbook of group communication theory and research.* 192–222.

Keyton, J. (2000). Introduction: The relational side of groups. *Small Group Research, 31*(4), 387–396. https://doi.org/10.1177/104649640003100401.

Kirkman, B. L., Rosen, B., Tesluk, P. E., & Gibson, C. B. (2004). The impact of team empowerment on virtual team performance: The moderating role of face-to-face interaction. *Academy of Management Journal,* 47: 175-192.

Klauss, R., & Bass, B.M. (1982). *Interpersonal communication in organizations.* Academic Press, New York.

Klitmøller, A., & Lauring, J. (2013). When global virtual teams share knowledge: Media richness, cultural difference and language commonality. *Journal of World Business,* 48(3), 398–406. https://doi.org/10.1016/j.jwb.2012.07.023

Kock, N., & Lynn, G. S. (2012). Electronic media variety and virtual team performance: The mediating role of task complexity coping mechanisms. *IEEE Transactions on Professional Communication,* 55, 325-344.

Kossler, M., & Prestridge, S. (1996). *Geographically dispersed teams, Issues and Observations* 16 (2/3), 9–11.

Krasnikov, A., & Jayachandran, S. (2008). The relative impact of marketing, research-and-development, and operations capabilities on firm performance. *Journal of Marketing,* 72, 1-11.

Lee-Kelley, L. (2002). Situational leadership: Managing the virtual project team. *Journal of Management Development*, 21(6), 461–476

Leonard, B. (2011). Managing virtual teams: Selection, engagement, communication and performance management matter when supervising employees who rarely meet face to face. *HR Magazine,* 56(6), 38–42.

Lin, C., Standing, C., & Liu, Y.C. (2008). A model to develop effective virtual teams. *Decision Support Systems*, 45 (4), 1031-1045, doi: 10.1016/j.dss.2008.04.002.

Lojeski, K.S., Reilly, R., & Dominick, P., (2007). Multitasking and innovation in virtual teams. *Proceedings of the 40th Annual Hawaii International Conference on System Sciences, 2007* (HICSS '07), Waikoloa, Hawaii.

Lojeski, K.S., Reilly, R.,& Dominick, P., (2006). The role of virtual distance in innovation and success. *Proceedings of the 39th Annual Hawaii International Conference on System Sciences, 2006* (HICSS '06), Waikaloa, Hawaii, 1–10.

Ludden, P. & Ledwith, A., (2014). A typology framework for virtual project teams: An empirical investigation, in C. Messikomer (ed.), PMI Research and Education Conference 2014, Project Management Institute, Portland, OR.

Lurey, J., & Raisinghani, M. (2001). An empirical study of best practices in virtual teams. *Information & Management,* 38(8), 523–544. https://doi.org/10.1016/S0378-7206(01)00074-X

Majchrzak, A., Rice, R., Malhotra, A., King, N., & Ba, S. (2000). Technology adaptation: The case of a computer-supported inter-organizational virtual team. *MIS Quarterly,* 24(4), 569-600. doi:10.2307/3250948

Marks, M. A., Mathieu, J. E., & Zaccaro, S. J. (2001). A temporally based framework and taxonomy of team processes. *Academy of Management Review*, 26, 356–376.

Marks, M. A., Zaccaro, S. J., & Mathieu, J. E. (2000). Performance implications of leader briefings and team-interaction training for team adaptation to novel environments. *Journal of Applied Psychology,* 85(6), 971–986.

Marlow, S.L., Lacerenza, C.N., & Salas, E. (2017). Communication in virtual teams: a conceptual framework and research agenda. *Hum Resource Management Rev,* 27(4), 575–589

Marotta,L., (2006). What are some of the major benefits for having virtual teams? http://www.web-conferencingzone.com/benefits-for-having-virtual-teams.htmS

Martins, L. L., Gilson, L. L., & Maynard, M. T. (2004). Virtual teams: What do we know and where do we go from here? *J. Manage.,* 30,(6), 805-835.

Maruping, L.M., & Agarwal, R. (2004). Managing team interpersonal processes through technology: A task-technology fit perspective. *J Appl Psychol,* 89(6), 975

Maznevski, M. L., & Chudoba, K. M. (2000). Bridging space over time: Global virtual team dynamics and effectiveness. *Organization Science*, 11, 473–492.

Maznevski, M. L., Davison, S., & Jonsen, K. (2006). Global virtual team dynamics and effectiveness. In G. Stahl & I. Bjorkman (Eds.), *Handbook of research in international human resource management,* 364–384.

McDonough, E. F., Kahn, K. B., & Barczak, G. (2001). An investigation of the use of global, virtual, and collocated new product development teams. *The Journal of Product Innovation Management,* 18, 110–120.

McGrath, J. (1984). *Groups Interaction and Performance*. Prentice-Hall, Englewood Cliffs, NJ.

McIntyre, R. M., & Salas, E. (1995). *Measuring and managing for team performance: Emerging principles from complex environments.* In R. Guzzo, & E. Salas (Eds.), *Team effectiveness and decision making in organizations,* 149–203. San Francisco: Jossey-Bass.

Mesmer-Magnus, J. R., DeChurch, L. A., Jimenez-Rodriguez, M., Wildman, J., & Shuffler,M. (2011). A meta-analytic investigation of virtuality and information sharing in teams. *Organizational Behavior and Human Decision Processes, 115*(2), 214–225. https://doi.org/10.1016/j.obhdp.2011.03.002

Mesmer-Magnus, J., & DeChurch, L. (2009). Information sharing and team performance. A meta-analysis. *Journal of Applied Psychology*, 94, 535–546.

Munkvold, B.E., & Zigurs, I., (2007). Process and technology challenges in swift-starting virtual teams. *Information & Management* 44 (3), 287–299.

Nabila, J., & Nabila, B. (2009). An exploratory study of the effects of virtuality on team effectiveness. *MCIS 2009 Proceedings*. 83.

Nader, A.E., Shamsuddin, A. & Zahari, T., (2009). Virtual teams: A literature review. *Australian Journal of Basic and Applied Sciences* 3(3), 2653–2669.

Neeley, T. B., Hinds, P. J., & Cramton, C. D. (2012). The (un)hidden turmoil of language in global collaboration. *Organizational Dynamics, 41*(3), 236–244. https://doi.org/10. 1016/j.orgdyn.2012.03.008.

Nunnally, J.C. (1978). *Psychometric Theory*, (2nd ed.). New York: McGraw-Hill.

Odenwald, S. (1996). Global work teams. *Training & Development*, 50: 54–57.

OGC (Office of the Government Commerce), (2009). Managing Successful Projects with PRINCE2™ . The Stationary Office, Norfolk, UK.

Oppenauer, V., & Van De Voorde, K. (2018). Exploring the relationships between high involvement work system practices, work demands and emotional exhaustion: A multi-level study. *The International Journal of Human Resource Management*, *29*(2),311–337.

Patrashkova-Volzdoska, R. R., McComb, S. A., Green, S. G., & Compton, W. D. (2003). Examining a curvilinear relationship between communication frequency and team performance in cross-functional project teams. *IEEE Transactions on Engineering Management,* 50(3), 262–269. https://doi.org/10.1109/TEM.2003.817298

Paul, S., Seetharaman, P., Samarah, I., & Mykytyn, P. P. (2004). Impact of heterogeneity and collaborative conflict management style on the performance of synchronous global virtual teams. *Information & Management,* 41, 303–321.

Penarroja, V., Orengo, V., Zornoza, A., & Hernandez, A. (2013). The effects of virtuality level on task-related collaborative behaviors: The mediating role of team trust. *Computers in Human Behavior,* 29, 967-974.

Petter, S., Straub, D., & Rai, A., (2007). Specifying formative constructs in IS research. *MIS Quarterly,* 31(4), 657-679.

Piccoli, G., Ahmad, R., & Ives, B. (2004). Web based virtual learning environment: a research framework and preliminary assessment of effectiveness in basic IT skills training. *MIS Quarterly,* 25(4), 401-426.

Pinar, T., Zehir, C., Kitapci, H. & Tanriverd, H., (2014). The relationships between leadership behaviours team learning and performance among the virtual teams. *International Business Research* 7(5), 68–79.

Pinto, J. K., & Slevin, D. P. (1988). Critical success factors in successful project management. *IEEE Transactions on Engineering Management*, 34(1), 22–27.

Pitagorsky, G. (2006). Virtual teams – Making your virtual team really human. PM Newsletter, 87.

Pitagorsky, G. (2007). Managing virtual teams for high performance. Paper presented at PMI® Global Congress 2007—North America, Atlanta, GA. Newtown Square, PA: Project Management Institute

Podsakoff, P. M., MacKenzie, S. B., Lee, J.-Y., & Podsakoff, N. P. (2003). Common method biases in behavioral research: A critical review of the literature and recommended remedies. *Journal of Applied Psychology,* 88(5), 879-903. doi: 10.1037/0021-9010.88.5.879

Polzer, J. T., Crisp, C. B., Jarvenpaa, S. L., & Kim, J. W. (2006). Extending the Faultline model to geographically dispersed teams: How co-located subgroups can impair group functioning. *The Academy of Management Journal, 49*(4), 679–692.

Poole, M. S., Holmes, M., & DeSanctis, G. (1991). Conflict management in a computer-supported meeting environment. Management Science, 37: 926–953.

Potter R.E. et al. (2002). Virtual team interaction styles: assessment and effects. *International Journal of Human-Computer Studies,* 56(4), 423-443(21).

Powell, A., Piccoli, G., & Blake, I. (2004). Virtual teams: a review of current literature and directions for future research. *ACM Sigmis Database*, 35(1),6-36. doi: 10.1145/968464.968467.

Pressman, R. S. (2001). Software Engineering: A Practitioner's Approach (5th ed). McGraw Hill, New York.

Project Management Institute (PMI). (2013). *A guide to the project management body of knowledge: PMBoK® guide*. Newtown Square, Township, PA.

Project Management Institute (PMI). (2014). *The high cost of low performance. PMI's pulse of the profession*. Newtown Square, Township, PA.

Project Management Institute. (2008a). A guide to the project management body of knowledge (*PMBoK* ® guide (4th ed.) Newtown Square, PA

Pullan, P., & Prokopi, E. (2016). Leading virtual project teams: dos and don'ts. Paper presented at PMI® Global Congress 2016—EMEA, Barcelona, Spain. Newtown Square, PA: Project Management Institute.

Purvanova, R.K., & Bono, J.E., (2009). Transformational leadership in context: face-to-face and virtual teams. *The Leadership Quarterly,* 20 (3), 343–357.

Rad, P.F., & Levin, G., (2006). *Achieving project management success using virtual teams*. J. Ross, Boca Raton, FL.

Rafaeli, S., & Ravid, G., (2003). Information sharing as enabler for the virtual team: an experimental approach to assessing the role of electronic mail in disintermediation. *Information Systems Journal,* 13(2), 191–206.

Rapp, A., Ahearne, M., Mathieu, J., & Rapp, T. (2010). Managing sales teams in a virtual environment. *International Journal of Research in Marketing,* 27, 213-224.

Ratcheva, V., & Vyakarnam, S. (2001). Exploring team formation processes in virtual partnerships. *Integrated Manufacturing Systems*, 12, 512–523.

Reyes, D. L., Luna, M., & Salas, E. (2021). Challenges for team leaders transitioning from face-to-face to virtual teams. *Organizational Dynamics*, *50*(2), 100785. https://doi.org/10.1016/j.orgdyn.2020.100785

Rezgui, Y., (2007). Exploring virtual team-working effectiveness in the construction sector, Interacting with Computers. *Moving face-to-face communication to web-based systems,* 19(1), 96–112.

Richter, A. (2020). Locked-down digital work. *International Journal of Information Management,* 55, 102-157. https://doi.org/10.1016/j.ijinfomgt.2020.102157.

Rico, R., & Cohen, S. G. (2005). Effects of task interdependence and type of communication on performance. *J. Manage. Psychol.*, 20, 261–274. doi: 10.1108/ 02683940510589046

Roman, A. V., Van Wart, M., Wang, X., Liu, C., Kim, S., & McCarthy, A. (2019). Defining e-leadership as competence in ICT-mediated communications: An exploratory assessment. *Public Administ. Rev.*, 79, 853–866. doi: 10.1111/puar.12980

RW3 CultureWizard (2014). retrieved online at 6/12/2016 http://www.prnewswire.com/news-releases/global-business-managers-depend-on-virtual-teams-forproductivity-268309892.html

RW3 CultureWizard (2016). retrieved online at https://www.rw-3.com/virtual-teams-survey-0?hsCtaTracking=a63b00ef-e098-4c0e-84e3-ebe086c27c4b%7C496cf8c6-b912-4885-981c-21213eaedcaf

RW3 CultureWizard (2020). 2020 Trends in Global Virtual Work. retrieved online at https://www.rw-3.com/virtual-teams-exec-report-2020

Sarker, S., Ahuja, M., Sarker, S. & Sarah, K. (2011). The role of communication and trust in global virtual teams: A social network perspective. *Journal of Management Information Systems,* 28(1), 273–309.

Sarker, S., Sarker, S., & Schneider, C. (2009). Seeing remote team members as leaders: A study of US-Scandinavian teams. *IEEE Transactions on Professional Communication*, 52: 75-94.

Schweitzer, L., & Duxbury, L. (2010). Conceptualizing and measuring the virtuality of teams. *Information Systems Journal,* 20(3), 267–295. https://doi.org/10.1111/j.1365-2575.2009.00326.x

Shachaf, P., & Hara, N. (2005). *Team effectiveness in virtual environments : An ecological approach*. INFERRIS, P.A.G., S., (Ed.) Teaching and Learning with Virtual Teams. Idea Group Publishing.

Shachaf, P., (2008). Cultural diversity and information and communication technology impacts on global virtual teams: An exploratory study. *Information & Management* 45 (2), 131–142.

Stagl, K. C., Salas, E., Rosen, M. A., Priest, H. A., Burke, C. S., Goodwin, G. F., & Johnston, J. H. (2007). *Distributed team performance: A multi-level review of distribution, demography, and decision making*. In F. Yammarino, & F. Dansereau (Eds.), Multi-level issues in organizations and time,11–58. Oxford, UK: Elsevier.

Stahl, G. K., Makela, K., Zander, L., & Maznevski, M. L. (2010). A look at the bright side of multicultural team diversity. *Scandinavian Journal of Management, 26*(4), 439–447. https://doi.org/10.1016/j.scaman.2010.09.009.

Stark, E., Bierly, P., & R. Harper, S. (2014). The interactive influences of conflict, task interdependence and cooperation on perceptions of virtualness in co-located teams. *Team Performance Management,* 20(5/6), 221-241. https://doi.org/10.1108/TPM-06-

Stout, R. J., Cannon-Bowers, J. A., & Salas, E. (1994). *The role of shared mental models in developing shared situational awareness*. In R. D. Gilson, D. J. Garland, & J. M.Quince (Eds.), Situation awareness in complex environments. Dayton Beach, FL: Embry-Riddle Aeronautical University Press.

Strang, K. D. (2011). Leadership substitutes and personality impact on time and quality in virtual new product development projects. *Project Management Journal,* 42, 73-90.

Straub, D., Boudreau, M.C., & Gefen, D. (2004 ). Validation guidelines for is positivist research. *Communications of the AIS,* 13(24), 380-427.

Studenmund, A. H. (1992). *Using econometrics: A practical guide*. New York: Harper Collins Publishers.

Suh, A., & Shin, K. S. (2010). Exploring the effects of online social ties on knowledge sharing: A comparative analysis of collocated vs dispersed teams. *Journal of Information Science,* 36: 443-463.

Tidwell, L. & Walther, J. (2002). Computer-mediated communication effects on disclosure, impression and interpersonal evaluations: Getting to know one another a bit at a time. *Human Communication Research,* 28(3), 317–348.

Turkay, S. & Tirthali, D. (2010). Youth leadership development in virtual worlds: A case study. *Procedia – Social and Behavioural Sciences*, 2(2), 3175-3179.

Velicia-Martin, F., Cabrera-Sanchez, J.P., Gil-Cordero, E., & Palos-Sanchez, P. R. (2021). Researching COVID-19 tracing app acceptance: incorporating theory from the technological acceptance model. *PeerJ Comput. Sci.* 7:e316. doi: 10.7717/peerj-cs.316

Venkatesh, V. (2020). Impacts of COVID-19: a research agenda to support people in their fight. *International Journal of Information Management,* 55, 102197. https://doi.org/10.1016/j.ijinfomgt.2020.102197.

Verburg, R., Bosch-Sijtsema, P., & Vartiainen, P. (2013). Getting it done: Critical success factors for project managers in virtual work settings. *International Journal of Project Management,* 31, 68–79.

Volkoff, O., Chan, Y., & Newson, E., (1999). Leading the development and implementation of collaborative interorganizational systems. *Information and Management* 35(2), 63–75

Von Glinow, M. A., Shapiro, D. L., & Brett, J. M. (2004). Can we talk, and should we? Managing emotional conflict in multicultural teams. *The Academy of Management Review, 29*(4), 578–592

Vorakulpipat, C., Rezgui, Y. & Hopfe, C.J., (2010). Value creating construction virtual teams: a case study in the construction sector. *Automation in Construction,* 19 (2), 142–147.

Walther, J.B. (1992). Interpersonal effects in computer-mediated interaction: a relational perspective. *Communication Research,* 19 (1) 52–90.

Warkentin, M. E., Sayeed, L., & Hightower, R. (1997). Virtual teams versus face-to-face teams: An exploratory study of web-based conference system. *Decision Sciences*, 28(4), 975–996.

Weisban, S. (2008). *Leadership at a Distance: Research in Technologically Supported Work*. Lawrence Erlbaun Associates Inc., New York, NY.

Woolley, A. W. (2009). Means vs. ends: Implications of process and outcome focus for team adaptation and performance. *Organization Science, 20*(3), 500–515. https://doi.org/10.1287/orsc.1080.0382.

Workman, M., Kahnweiler, W., & Bommer, W., (2003). The effects of cognitive style and media richness on commitment to telework and virtual teams. *Journal of Vocational Behavior,* 63: 199–219.

Yoo, Y., & Alavi, M. (2004). Emergent leadership in virtual teams: what do emergent leaders do? *Information and Organization,* 14(1), 27–58. https://doi.org/10.1016/j.infoandorg.2003.11.001

Zigon, J., (2000). Team performance: A process for creating team performance standards. *Management: Compensation and Benefits Review* 29(1), 38–47. http://dx.doi.org/10.1177/088636879702900106

Zigurs,I., (2003). Leadership in virtual teams: Oxymoron or opportunity? *Organizational Dynamics* 31(4),339–351.