DEMOGRAPHIC AND EXPERIENTIAL INFLUENCES ON TRUST AND TECHNOLOGICAL COMPETENCY PERCEPTIONS IN VIRTUAL PROJECT TEAMS

Feiyang Wei, Bon-Gang Hwang
National University of Singapore

Abstract
With the widespread implementation of virtual project teams (VPTs) in the built environment industry, it is essential to recognize the importance of the factors that influence trust and technological competency in virtual environments. Existing research has overlooked the variation in how these factors are valued by individuals with different characteristics. To address this gap, this study aims to: (1) identify key factors influencing trust and technological competency in VPTs, (2) examine whether perceptions of importance vary across respondent characteristics, and (3) explore how demographic and experiential diversity shapes these perceptions. A comprehensive literature review was first conducted to identify key influencing factors. Subsequently, a questionnaire was provided in a structured format, and a series of non-parametric tests were applied in the analysis of changes in perceived factor importance. The findings suggested that designation, age, level of education and construction sector experience are strongly correlated with perceptions, whereas gender is not. For instance, construction managers and architects emphasized organizational citizenship and ability to plan, and younger and older respondents emphasized higher levels of benevolence and commitment. This study contributes to academics by providing empirical insight into perceptions of competency and trust in VPTs. At the practical aspect, it offers targeted training and team-building approaches for VPTs based on demographic characteristics and experiential backgrounds.

Keywords: Trust, Technological Competency, Virtual Project Teams, Perceived Importance

Introduction

Background and Motivation

Increased application of virtual project teams (VPTs) in the built environment sector is reshaping traditional forms of project collaboration, enabled by post-pandemic changes in workplaces and advancements in digital technology (Assaad & El-adaway, 2021; Baker et al., 2020). This reshaping, motivated by decentralized operations and digitalized value chains brought about by the Fourth Industrial Revolution (4IR), has brought into sharp relief the importance of trust in leadership of distributed teams (Paul et al., 2020; Rezgui, 2007). VPTs enable geographically distant professionals to collaborate through digital platforms (Alsharo et al., 2017), but challenges such as reduced social cues, asynchronous interaction, and fluctuating team dynamics complicate building trust (Breuer et al., 2020; Kaur et al., 2016; Robert Jr et al., 2009).

With regard to VPTs, trust is a crucial element in fostering collaboration, knowledge transmission, and effective coordination (Breuer et al., 2020; Kunkcu et al., 2025; Schiller & Mandviwalla, 2007), theorized as a willingness to embrace vulnerability based on hopeful expectations of other players in the team (Mayer et al., 1995; McAllister, 1995). Several factors come into consideration when it involves trust building in VPTs, such as organizational culture, leadership, and individual reliability (Breuer et al., 2020; J. V. Hacker et al., 2019; Watanuki & Moraes, 2022). However, digital platforms impose limitations upon classical mechanisms of trust (Kasper-Fuehrer & Ashkanasy, 2001), in need of new means based on technological expertise. Technological ability, defined as being competent in terms of being able to utilize information communication technologies in a proficient manner for purposes of better communication, coordination, and resolution of problems, has then been a determining factor in trust building and enhancement of performance based on a platform that is virtual (Moradi et al., 2021; Wei et al., 2023). Beyond technical skills, it includes knowledge of project management, familiarity with collaborative tools, adaptability to digital change, and positive attitudes toward emerging technologies such as AI and cloud systems (Fekry Youssef et al., 2023; Ngo & Hwang, 2022).

Although various studies have examined trust and competency in virtual settings, few have investigated how individual differences, such as designation, age, gender, education level and experience, affect perceptions of trust-related and competency-related factors (Flavian et al., 2019; Watanuki & de Oliveira Moraes, 2022). Given the built environment industry's unique reliance on multidisciplinary collaboration, high project turnover, and varying levels of digital maturity (Garro-Abarca et al., 2021; J. Hacker et al., 2019), understanding such perceptual differences is essential for targeted interventions. Therefore, this study aims to address this gap by: (1) identifying the key factors influencing trust and technological competency in VPTs; (2) examining whether perceptions of importance vary across different respondent characteristics; and (3) exploring how demographic and experiential diversity shapes the perceived importance of key factors related to trust and technological competency in VPTs. By revealing how perceptions of both trust-related and technological competency-related factors, each contributing to the formation of trust, vary across respondent profiles, this study offers a more nuanced understanding of trust building in VPTs. These findings allow project leaders and organizations to develop specific trust-building strategies that can be adapted according to different team configurations and levels of digital readiness. The study also contributes theoretically by integrating individual and technological dimensions into a unified trust-building perspective, advancing current knowledge on virtual collaboration in the built environment sector.

Three-Level Antecedents of Trust in Virtual Project Teams

The building of trust within VPTs is shaped by the integrated influence of multiple factors at the organizational, project team and individual levels. Following fundamental research work (Jarvenpaa & Leidner, 1999; Robert Jr et al., 2009; Staples & Webster, 2008), a multi-level approach is adopted in this work to delineate and categorize such antecedents in favor of a formalized trust-building approach in virtually mediated project environments.

Organizational-level influences impact trust by ensuring an enabling environment through cultural, managerial, and technological dimensions. Collaborative culture supported by communal norms promotes psychological safety in the absence of face-to-face cues (Schein, 2010; Alsharo et al., 2017). Top management's commitment induces trust by providing a signal of strategic intent and committing resources toward collaborative work virtually (Ford et al., 2017). Trust is enhanced by effective IT infrastructure and knowledge management tools ensuring reliable communication and transparent procedures (Henttonen & Blomqvist, 2005; Holste & Fields, 2010; Morley et al., 2015). Human resource practices including skills training in collaborative work, fair appraisal, and rewards for collaborative work promote trustworthiness in teams (Germain & McGuire, 2014; Panteli & Tucker, 2009). Leadership is a very important influencer in demonstrating integrity, balanced monitoring, and enforcement of organizational citizenship behavior (Colbert et al., 2016; Ehrhart & Naumann, 2004).

Project teams may be formed within or across organizations to achieve a set goal. Team familiarity, clear role definition, and knowledge exchange are central to trust formation (Breuer et al., 2020; Robert Jr et al., 2009). Transformational leadership, which aligns vision and fosters inclusion, helps sustain trust in diverse and geographically dispersed teams (Chinowsky & Rojas, 2003; Zaccaro et al., 2001). ICT-supported communication tools and regular, clear information flows reduce uncertainty and misunderstandings in virtual collaboration (Marlow et al., 2017; Rezgui, 2007). Trust is further reinforced when team members share values, respect diverse perspectives, and follow transparent decision-making processes (J. Hacker et al., 2019; Stewart & Gosain, 2006). Importantly, virtual teams require a careful balance of autonomy and coordination, with task interdependence and diversity potentially increasing trust when managed constructively (Pinjani & Palvia, 2013; Stahl et al., 2010).

Individual-level factors relate to team members' personal traits and behaviors. Reliability, integrity, and task competence are core to establishing interpersonal trust (Barber, 1983; Mayer et al., 1995). Demonstrating accountability and consistency signals trustworthiness in digital settings (Cook & Wall, 1980; Robert Jr et al., 2009). Emotional engagement—through empathy, proactive communication, and mutual respect—also facilitates affect-based trust (Grant & Ashford, 2008; Williams, 2001). Cultural awareness and sensitivity help reduce interpersonal friction in diverse teams, while ethical conduct strengthens perceived integrity (Burke et al., 2007; Stahl & Tung, 2015). Conversely, identity-based conflict or inconsistent behavior undermines trust, especially in high-uncertainty digital contexts (Lewicki et al., 2006). Fig. 1 shows the summary of three-level trust influencing factors in VPTs.

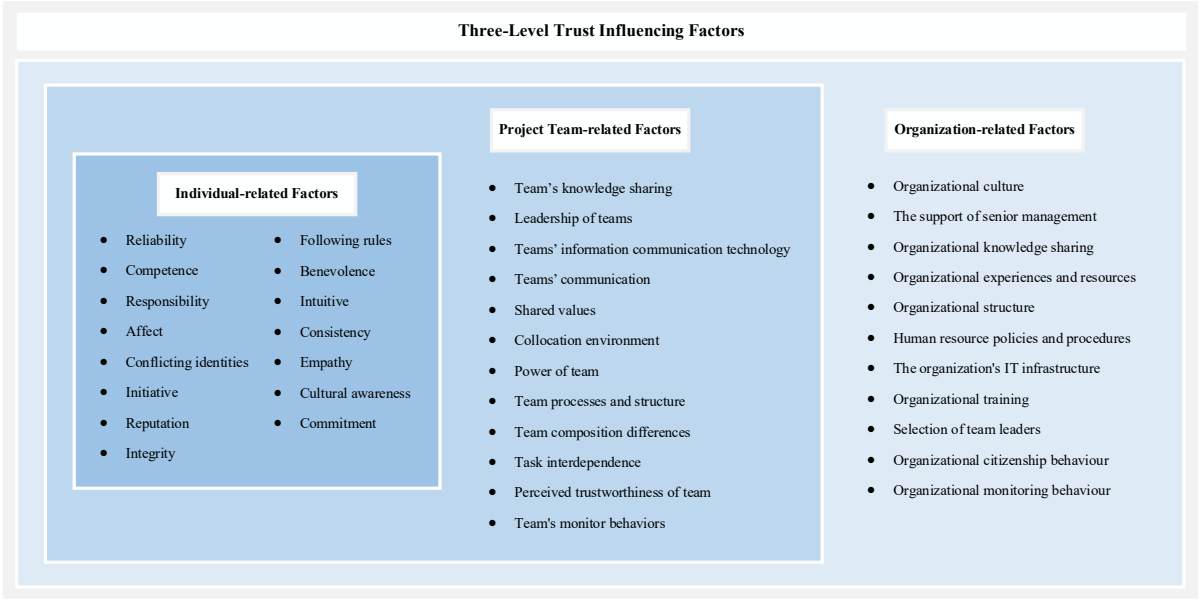

Fig. 1 *Three-Level Trust Influencing Factors in Virtual Project Teams*

In conclusion, trust building in VPTs is governed by a three-dimensional set of factors that span organizational support, project team dynamics and individual interactions. Despite the availability of rich literature, most studies have examined these factors in isolation, and few have explored how their perceived importance varies across individual backgrounds. This study addresses this gap by assessing the relative importance of trust antecedents across respondent characteristics such as role, age, gender and experience, offering more tailored insights for building trust in the built environment sector.

Technological Competency to Facilitate Trust Building in Virtual Project Teams

Beyond trust influencing factors, the success of VPTs hinges on the technological competency of their members. This construct is critical for sustaining trust and performance in digitally mediated environments, encompassing the knowledge, skills and personal attributes required to navigate virtual collaboration effectively (Wei et al., 2023).

Knowledge is the intellectual basis of operations in the virtual environment. Well-established project management knowledge bases, such as PMBOK and IPMA ICB4, offer guidance in a wide range of areas such as scope, schedule, cost, and stakeholder management, which are no less fundamental in virtual environments (IPMA, 2017; PMI, 2017; Vukomanović et al., 2016). Such foundational knowledge, however, is complemented in VPTs by digital competence, including platform-specialized skills, knowledge of cybersecurity, and cloud-based collaboration tool knowledge (Kimble, 2011; Malhotra, 2000). The onset of AI-powered project facilities, such as predictive analysis, sentiment analysis, and digital assistant, introduces new layers of required knowledge, thereby placing a greater emphasis on technological competence in establishing transparency, communications, and trustworthiness (Flak & Pyszka, 2022; Woolley et al., 2023).

Skills are the applied abilities necessary to traverse remote collaborative work complexities. Beyond core ICT skills, participants in VPTs must have abilities in collaboration, decision-making, conflict resolution, time management, and electronic communication (Alvarenga et al., 2019; Voogt & Roblin, 2012). Skills such as active listening, staying composed, and effective delegation are particularly vital in low-context environments, where nuanced signs may not exist (Creasy & Anantatmula, 2013). Moreover, analysis ability, effective tool handling, and management of distributed work setups are essential in the context of the 4IR (Kimble, 2011; Van Laar et al., 2017). These abilities not only increase functional efficiency but also transmit a sense of ability and reliability, which are building blocks for developing trust in VPTs.

Personal Attributes, covering individual traits as well as attitudinal elements, are a major constituent of a technologically competent member of a project team. Key traits are flexibility, proactivity, emotional control, leadership, and analytical thinking (Brill et al., 2006; Spencer & Spencer, 1993). Under circumstances of formal interactions in a virtual space, these attributes play a crucial role in maintaining cohesion and trust. Proactivity in forms of information-seeking behavior and exercising influence facilitate communication beyond time zones and organizational boundaries (Maznevski & Chudoba, 2000; Zaccaro & Bader, 2003). Teamwork, self-control and diffuse leadership in a VPT reinforce mutual dependency and reduce perceived risk in remote collaboration (Bell & Kozlowski, 2002; Hertel et al., 2005). Attitudinal elements, such as Perceived Usefulness (PU), Perceived Ease of Use (PEU), Technology Self-Efficacy (TSE), Technology Affect (TAFF), Technology Anxiety (TANX), and Personal Innovativeness in IT (PIT), have been demonstrated in previous research to collectively shape these attitudes (Wei et al., 2023). Therefore, in this

study, no deeper investigation into the attitudinal aspects will be conducted. Fig. 2 shows the technological competency required in VPTs.

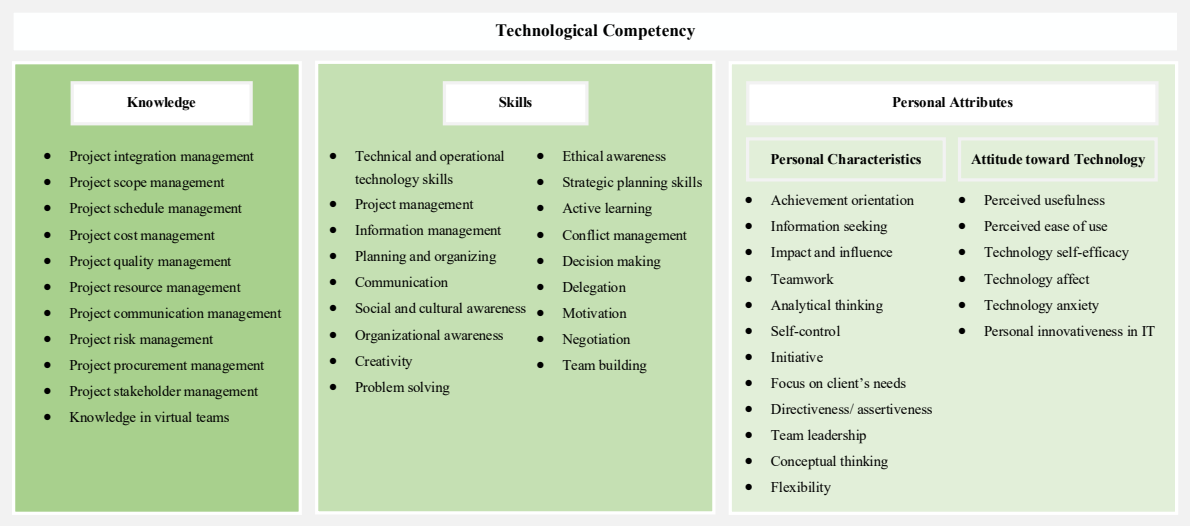

Fig. 2 *Technological Competency Required for Virtual Project Teams*

In summary, technological competency encompasses knowledge, skills, and personal attributes which collectively facilitate the building of trust within VPTs. Existing studies have not fully explored how these components enhance trust, particularly in contexts characterized by different team compositions. This study addresses this gap by positioning technological competency as a core category within the three-level antecedents of trust, contributing to a more comprehensive understanding of how VPTs in the built environment industry can succeed in an increasingly digital context.

Methodology

This study adopted a four-phase approach to explore how different respondent characteristics influence the perceived importance of factors influencing trust and technological competency in VPTs.

Phase 1: Literature Review

The research began with an extensive review of relevant academic literature to identify key antecedents of trust across organizational, project team and individual levels, along with the knowledge, skills and personal attributes constituting technological competency. The selection of these factors was guided by their frequency in previous studies and contextual relevance to the built environment sector's virtual collaboration demands.

Phase 2: Questionnaire Design and Expert Validation

Insights from the literature were used to construct a structured questionnaire designed to assess the importance of the identified factors. To ensure conceptual clarity and content validity, the survey instrument was reviewed by six experienced professionals from the built environment industry, including senior project managers, engineers and digital collaboration experts, each with over ten years of experience in managing VPTs. These experts evaluated the terminology, definitions and factor descriptions to ensure they were precise, industry-relevant and understandable for a professional audience. Feedback from this pilot interview was used to refine the questionnaire, improve wording and ensure comprehensive coverage of the targeted constructs. Table 1 presents the background of the expert panel.

Table 1 *Profile of Expert Interviews*

No.	Position	Organization Type	Years of Experience
P1	Professor	University	11
P2	Technical director	Contractor	16
P3	Principal project manager	Government	12
P4	Project manager	Contractor	11
P5	Professor	University	21
P6	Project manager	Developer	23

Phase 3: Data Collection

The finalized questionnaire was distributed to industry practitioners to capture their evaluations of the importance of trust-related and technological competency-related factors. Respondents rated the factors on a seven-point Likert scale (1 = not important at all, 7 = very important) based on their perceived significance in VPT settings. The survey also captured demographic and professional information, including designation, age, gender, educational background and years of experience in the construction industry.
The survey questionnaire was distributed using a random sampling method across a range of organizations identified through publicly accessible sources, including the websites of the Singapore Society of Project Managers (SPM), the Building and Construction Authority (BCA) Directory of Registered Contractors and Licensed Builders, the Singapore Institute of Architects (SIA), the Real Estate Developers' Association of Singapore (REDAS), and the Institution of Engineers Singapore (IES). The target participants were industry professionals such as Project Managers, Contractors, Consultants, Engineers, Architects, and Facilities Managers. A total of 800 professionals in the built environment industry were invited to participate, resulting in 110 complete questionnaires and a response rate of 13.75%. This falls within the acceptable range for external surveys, typically between 10% and 15% (Fryrear, 2015), and aligns with the average response rate reported for construction industry surveys in Singapore (Liao & Teo, 2019; Teo et al., 2007). Table 2 shows the profile of respondents.

Table 2 *Profile of Respondents*

Characteristic	Description	Frequency	Percentage
Respondent's Designation	Architect	8	7.30
	Project Manager	19	17.30
	Quantity Surveyor	17	15.50
	Engineer	25	22.70
	Contractor	5	4.50
	Construction Manager	3	2.70
	Facilities Manager	4	3.60
	Technology Manager	10	9.10
	Others	19	17.30
Respondent's Years of Experience in the Construction Industry	Less than 5 years	52	47.30
	5 to 10 years	35	31.80
	More than 10 years	23	20.90
Respondent's Age	Less than 25 years old	13	11.80
	25 to 34 years old	67	60.90
	35 to 44 years old	17	15.50
	45 to 54 years old	11	10.00
	More than 55 years old	2	1.80
Respondent's Gender	Male	78	70.90
	Female	32	29.10

Respondent's Education	Diploma and below Bachelor's Degree Postgraduate Degree	15 64 31	13.60 58.20 28.20
Total		110	100.00

Phase 4: Data Analysis

The final phase included descriptive and inferential statistical analysis in determining perceived importance in trust building factors and technological competency in VPTs. Descriptive analysis included frequency distributions and mean rank scores for all factors, providing a general trend in evaluation among respondents.

The initial calculation of Cronbach's alpha aims to evaluate internal consistency as well as reliability in response through each of the factor categories (Tavakol & Dennick, 2011). The Shapiro-Wilk test was then adopted in determining normality in data acquired, and it was discovered to have non-normal distributions (Hanusz et al., 2016). Non-parametric tests were therefore used in subsequent analysis.

For assessing significant factors, a one-sample Wilcoxon signed-rank test was conducted with a neutral median value of 4 from 7-point Likert scales adopted in the questionnaire (Joshi et al., 2015; Woolson, 2005). Those factors, which had p-values lower than 0.05 and medians greater than 4, were considered significantly influential in contributing to trust and technological competency in VPTs (Hwang et al., 2020).

For examining perceptual differences along respondent attributes, Kruskal-Wallis tests were applied in order to detect significant differences in factor importance scores in groups defined based on respondents' designation, age, gender, level of education and construction sector experience (McKight & Najab, 2010). Where statistically significant differences were identified, the Mann-Whitney U test was used for pairwise comparisons to determine which specific respondent groups exhibited those differences (Nachar, 2008). All inferential tests were conducted at a 0.05 significance level (Hwang et al., 2020; Nwaogu et al., 2022).

Findings

Perceived Differences in Trust Influencing Factors Across Respondent Characteristics

As shown in Table 3, the Kruskal-Wallis test results revealed several statistically significant differences in the perceived importance of trust influencing factors across various respondent characteristics. Specifically, designation was associated with differences in the evaluation of organizational citizenship behaviour. Age was linked to differences in the importance of benevolence and commitment, while no significant differences were observed based on gender. Educational background significantly influenced perceptions of the support of senior management. For respondents with varying years of experience in the construction industry, significant differences emerged in relation to organizational training, selection of team leaders, and collocation environment. These results highlight the nuanced ways in which respondent characteristics shape perceptions of factors influencing trust and technological competency in virtual project environments.

Table 3 *Results of the Kruskal Wallis Test for Trust Influencing Factors*

Respondents' Characteristics	Trust Influencing Factors with Differences in Importance	Factor Category	Kruskal Wallis Test
Designation	Organizational citizenship behaviour	Organization-related Factors	0.041*
Age	Benevolence	Individual-related Factors	0.036*
	Commitment	Individual-related Factors	0.027*
Gender	N.A.		

Education	The support of senior management	Organization-related Factors	0.029*
Years of Experience in the Construction Industry	Organizational training	Organization-related Factors	0.017*
	Selection of team leaders	Organization-related Factors	0.024*
	Collocation environment	Project Team-related Factors	0.049*

*Significant at p-value <0.05

Perceived Differences in Technological Competency Across Respondent Characteristics

As shown in Table 4, the Kruskal-Wallis test results revealed significant differences in the perceived importance of various technological competency factors across multiple respondent characteristics. Designation was associated with differences in the evaluation of planning and organizing. No significant differences were observed by age or gender. Additionally, educational background showed a significant effect on perceptions of information seeking. Respondents with varying levels of experience in the construction industry differed significantly in their evaluation of team leadership and flexibility, indicating variation in how personal attributes are valued based on industry exposure. These results indicate that professional background and experience, particularly with virtual environments, significantly shape how technological competency factors are perceived and prioritized.

Table 4 *Results of the Kruskal Wallis Test for Technological Competency Factors*

Respondents' Characteristics	Technological Competency Factors with Differences in Importance	Factor Category	Kruskal Wallis Test
Designation	Planning and organizing	Skills	0.021*
Age	N.A.		
Gender	N.A.		
Education	Information seeking	Personal Characteristics	0.044*
Years of Experience in the Construction Industry	Team leadership	Personal Characteristics	0.018*
	Flexibility	Personal Characteristics	0.031*

*Significant at p-value <0.05

Discussion and Conclusion

Discussion

Variation in Perceived Importance by Respondents' Designation

The analysis revealed that perceptions of the importance of organizational citizenship behaviour (OCB) as a trust-building factor varied significantly across professional designations. While most roles rated OCB above the neutral midpoint, notable differences were observed in both the magnitude and ranking of its importance. Architects and Construction Managers rated OCB particularly highly, both assigning it the top rank among organizational-related factors, with mean scores of 5.56 and 6.00 respectively. In contrast, Project Managers and respondents categorized as "Others" rated this factor significantly lower, both placing it at the bottom of their respective rankings. Mann-Whitney U test results further confirmed these differences, as shown in Table 5 and Table 6. Project Managers rated OCB significantly lower than Architects and Quantity Surveyors, while significant differences were also found between Project Managers and Construction Managers. Additionally, the "Others" group rated OCB significantly lower than Architects,

Quantity Surveyors, and Construction Managers. These results suggest that while OCB is broadly recognized as important, its perceived value in fostering trust may be influenced by respondents' roles and responsibilities within VPTs (Kiffin-Petersen et al., 2012; Lewicki et al., 2006).

Table 5 *Results of the Mann-Whitney U Test of Organizational Citizenship Behaviour for Respondents' Designation*

	PM	QS	ENG	CTR	CM	FM	TM	OTH
ARC	0.025*	0.561	0.133	0.364	0.940	0.050	0.243	0.042*
PM		0.011*	0.244	0.446	0.009*	0.409	0.211	0.795
QS			0.199	0.587	0.342	0.033*	0.332	0.042*
ENG				0.888	0.133	0.246	0.912	0.309
CTR					0.413	0.413	0.953	0.446
CM						0.029*	0.106	0.035*
FM							0.142	0.557
TM								0.403

ARC: Architect, PM: Project Manager, QS: Quantity Surveyor, ENG: Engineer, CTR: Contractor, CM: Construction Manager, FM: Facilities Manager, TM: Technology Manager, OTH: Others
*Significant at p-value <0.05

Table 6 *Results of the Mean and Rank of Organizational Citizenship Behaviour for Respondents' Designation*

Designation	Median	Mean	Ranking within Designation Category
Architect	6.0	5.56	1
Project Manager	4.0	3.84	11
Quantity Surveyor	5.0	5.22	2
Engineer	5.0	4.45	9
Contractor	5.0	4.60	2
Construction Manager	6.0	6.00	1
Facilities Manager	3.0	3.25	6
Technology Manager	4.5	4.60	7
Others	4.0	3.84	11

These differences may reflect fundamental differences in role functions, trust expectations, or management orientations. Roles that focus on team coordination and supervision (e.g., Architects and Construction Managers) tend to value proactive collaborative behaviors, which form the basis of shared responsibility and team cohesion (Breuer et al., 2016; Hudson, 2022). Conversely, Project Managers may prioritize formal structures or performance accountability mechanisms over discretionary actions (Zheng et al., 2023; Zuofa & Ochieng, 2021). Low ratings from the "Other" group (which includes more specialized or marginalized roles) may indicate a disconnect in these roles' perception or experience of collective behavioral norms within the VPT (Hosseini et al., 2019).

Moreover, respondents from different designations showed significant variations in their perception of the importance of planning and organizing skills. Descriptive statistics reveal that Architects, Construction Managers, and Technical Managers all placed a high priority on this skill, with average scores of 5.78, 6.75 and 6.00, respectively. All groups ranked this skill at or near the top among the skill-related items. In contrast, Project Managers ranked this skill much lower, with an average score of just 4.05. Mann-Whitney U test results further revealed several statistically significant differences in the perceived importance of this factor, as shown in Table 7 and Table 8. Project Managers rated it significantly lower than Architects,

Construction Managers, Technology Managers, and respondents categorized as "Others." Additionally, Quantity Surveyors and Engineers also differed significantly from Construction Managers in their evaluations. These differences suggest that while planning and organizing skills are broadly acknowledged as relevant, their relative value varies depending on professional role and task focus (Galanti et al., 2023).

Table 7 *Results of the Mann-Whitney U Test of Planning and Organizing for Respondents' Designation*

	PM	QS	ENG	CTR	CM	FM	TM	OTH
ARC	0.028*	0.194	0.208	0.606	0.414	0.076	1.000	0.595
PM		0.159	0.116	0.183	0.009*	0.907	0.009*	0.040*
QS			0.991	0.691	0.010*	0.227	0.057	0.298
ENG				0.671	0.030*	0.246	0.092	0.348
CTR					0.111	0.190	0.371	0.783
CM						0.029*	0.304	0.188
FM							0.036*	0.162
TM								0.573

ARC: Architect, PM: Project Manager, QS: Quantity Surveyor, ENG: Engineer, CTR: Contractor, CM: Construction Manager, FM: Facilities Manager, TM: Technology Manager, OTH: Others
*Significant at p-value <0.05

Table 8 *Results of the Mean and Rank of Planning and Organizing for Respondents' Designation*

Designation	Median	Mean	Ranking within Designation Category
Architect	7.0	5.78	8
Project Manager	4.0	4.05	16
Quantity Surveyor	5.0	5.00	8
Engineer	5.0	4.97	4
Contractor	5.0	5.40	1
Construction Manager	7.0	6.75	1
Facilities Manager	3.5	4.00	11
Technology Manager	6.0	6.00	1
Others	6.0	5.37	9

These results may indicate specialized responsibilities and coordination interactions inherent in professional designations. For example, Construction Managers and Technology Managers would generally work in multifaceted, multi-tiered coordination arrangements necessitating very formalized forms of planning methods, particularly in virtual project environments (Ale Ebrahim et al., 2009; Galanti et al., 2023). Architects may appreciate this skill to a comparable degree as a consequence of their roles in managing schedules of design evolution and coordination with heterogeneous stakeholders (Limsila & Ogunlana, 2008; Sun et al., 2014). Project Managers, however, may regard this skill as a component of larger leadership or management skills, or may emphasize implementation and resolution choices over initial procedures in virtual environments themselves (Morley et al., 2015; Paton & Hodgson, 2016). The substantial difference between Construction Managers and Quantity Surveyors is muted as well in recognition of a discrepancy between roles aimed at process coordination and those for cost measurement or record-keeping (Burcin Becerik-Gerber et al., 2012; Zhu et al., 2022). Therefore, this plurality of viewpoints highlights a requirement for localization of instruction and developmental programs in concert with VPT requirements for roles.

Changing Perceptions of Importance Across Age Groups

Analysis of the data reveals that among the individual factors associated with building trust, only the factors of goodwill and commitment show statistically significant differences between different age groups. Descriptive analysis indicates that respondents under the age of 25 consistently gave these two factors the highest ratings, with commitment ranking first. In contrast, respondents aged 25 to 44 generally assigned lower scores to both items. Ratings began to increase again in the older age groups, particularly among those over 55, who rated both factors at or near the highest level. Mann-Whitney U test results confirmed these age-related differences as shown in Table 9, Table 10 and Table 11. For benevolence, respondents under 25 rated it significantly higher than those aged 25 to 34 and 45 to 54. For commitment, respondents under 25 also rated it significantly higher than those aged 35 to 44, while respondents aged 45 to 54 rated it significantly higher than those in the 35 to 44 group.

Table 9 *Results of the Mann-Whitney U Test of Benevolence for Respondents' Age*

	25 to 34 years old	35 to 44 years old	45 to 54 years old	>55 years old
<25 years old	0.005*	0.077	0.041*	0.800
25 to 34 years old		0.404	0.800	0.155
35 to 44 years old			0.525	0.238
45 to 54 years old				0.308

*Significant at p-value <0.05

Table 10 *Results of the Mann-Whitney U Test of Commitment for Respondents' Age*

	25 to 34 years old	35 to 44 years old	45 to 54 years old	>55 years old
<25 years old	0.062	0.002*	0.955	0.933
25 to 34 years old		0.086	0.163	0.540
35 to 44 years old			0.016*	0.190
45 to 54 years old				0.923

*Significant at p-value <0.05

Table 11 *Results of the Mean and Rank of Benevolence and Commitment for Respondents' Age*

Factors	Age	Median	Mean	Ranking within Age Category
Benevolence	<25 years old	6	5.85	2
	25 to 34 years old	5	4.43	14
	35 to 44 years old	5	4.74	5
	45 to 54 years old	4	4.36	12
	>55 years old	6	6	2
Commitment	<25 years old	6	6.08	1
	25 to 34 years old	5	5.1	2
	35 to 44 years old	4	4.42	12
	45 to 54 years old	6	5.82	1
	>55 years old	6	6	2

These patterns suggest a U-shaped perception curve, where both the youngest and oldest professionals place greater importance on benevolence and commitment in trust formation compared to mid-career individuals. Younger respondents may idealize interpersonal trust and dedication, possibly due to limited exposure to project-based pressures and more optimistic expectations regarding teamwork (Carrier et al., 2015; Dewa et al., 2019). Conversely, older professionals with more leadership experience, may reaffirm the value of these traits through their accumulated organizational learning (Badrinarayanan, 2024; Hincapie & Costa, 2024; Mutha & Srivastava, 2023). At the same time, mid-career professionals may focus

more on technical or performance-oriented approaches to building trust, reflecting shifting priorities across career stages (Ngo & Hwang, 2022). This finding emphasizes the importance of adapting trust-building strategies within VPTs to account for generational differences. The findings also suggest that leadership styles that emphasize benevolence and visible commitment may resonate more with both new and old employees, promoting cohesion within age-diverse teams (Ben Sedrine et al., 2021; Sagar et al., 2023).

Consistency in Gender-Based Perceived Importance

The findings indicated that gender does not exert a statistically significant influence on perceptions of the importance of factors related to trust or technological competency. Across all dimensions examined, responses from male and female participants demonstrated high consistency, with no significant differences observed in their rankings or average scores.

This absence of gender differences may reflect the increasing normalization of virtual collaboration practices within the built environment industry, particularly as digital tools and remote communication become standard configurations for project delivery (Faqih, 2022; Flavián et al., 2022). It may also indicate that perceptions of VPT credibility or technical capability increasingly depend on role positioning or accumulated experience, rather than demographic identity (Faqih, 2022; Furumo & Pearson, 2007).

From a practical standpoint, the results imply that trust-building initiatives and technology competency development programs in virtual project settings may not require gender-specific customization (Furumo & Pearson, 2007; Krebs et al., 2006). Instead, greater emphasis may be placed on aligning strategies with professional role, organizational culture or levels of industry experience (Badrinarayanan, 2024; Flavián et al., 2022). However, it is also important to acknowledge that while no statistical differences were detected, this does not necessarily imply that gender plays no role in team dynamics or collaboration outcomes. Subtle, qualitative differences may still emerge in how individuals engage with trust-building processes or digital tools, particularly in culturally diverse or male-dominated project environments (Faqih, 2022; Wong et al., 2004). Future research may benefit from exploring intersectional factors or incorporating mixed-method approaches to uncover deeper nuances that may not be captured through quantitative analysis alone.

Educational Background as a Distinguishing Perspective

The findings revealed significant differences in how respondents with varying educational backgrounds perceive the importance of the support of senior management and information seeking in the context of trust-building and technological competency in VPTs.

Respondents holding a diploma or below rated the support of senior management (with a mean score of 3.65) notably lower, compared to those with a bachelor's degree and postgraduate degree. Mann-Whitney U tests confirmed that these differences were statistically significant between diploma holders and both bachelor's and postgraduate degree holders, as shown in Table 12 and Table 13. This pattern suggests that individuals with higher education may more strongly recognize the strategic role of senior management in facilitating trust through organizational alignment, resource provision, and leadership visibility in virtual environments (Darban, 2023; Hooghe et al., 2012; Jin, 2024; Tucker et al., 2023). In contrast, diploma-level respondents might focus more on task-level or operational dynamics, perceiving top-down support as less directly impactful (Hooghe et al., 2012; Mirfardi, 2011).

Table 12 *Results of the Mann-Whitney U Test of the Support of Senior Management for Respondents' Education Level*

	Bachelor's degree	Post graduate degree
Diploma and below	0.012*	0.019*
Bachelor's degree		0.547

*Significant at p-value <0.05

Table 13 *Results of the Mean and Rank of the Support of Senior Management for Respondents' Education Level*

Education Level	Median	Mean	Ranking within Education Category
Diploma and below	3.0	3.65	11
Bachelor's degree	5.0	4.94	2
Post graduate degree	5.0	4.81	6

Similarly, information seeking, a personal characteristic vital to technological competency, showed marked differences across educational levels. Those with a diploma or below assigned it the lowest importance, compared to significantly higher importance means among those with bachelor's and postgraduate degrees. Mann-Whitney U tests indicated significant differences between the diploma group and both of the higher education groups, as shown in Table 14 and Table 15. This finding suggests that more highly educated professionals may place greater emphasis on proactive information behaviors as a foundation for digital collaboration, adaptability, and innovation, particularly relevant in the knowledge-driven settings of VPTs (Hooghe et al., 2012; Mirfardi, 2011). It may also reflect the training emphasis or cognitive preferences encouraged through formal education, which prioritize independent learning and strategic exploration of digital tools (Cruz-Jesus et al., 2016; Elena-Bucea et al., 2021).

Table 14 *Results of the Mann-Whitney U Test of Information Seeking for Respondents' Education Level*

	Bachelor's degree	Post graduate degree
Diploma and below	0.035*	0.015*
Bachelor's degree		0.434

*Significant at p-value <0.05

Table 15 *Results of the Mean and Rank of Information Seeking for Respondents' Education Level*

Education Level	Median	Mean	Ranking within Education Category
Diploma and below	3.0	3.82	12
Bachelor's degree	5.0	4.99	3
Post graduate degree	6.0	5.38	2

In summary, these findings emphasize the importance of considering educational backgrounds when designing interventions aimed at enhancing confidence and technological competency in VPTs. Training programs should be tailored not only according to roles or experience, but also according to educational attainment levels, ensuring effective communication between all levels of employees and promoting organizational support structures for cognitive and proactive information handling behaviors (Elena-Bucea et al., 2021; Lyhreatis et al., 2022).

Influence of Construction Industry Experience on Perceived Importance

The findings indicated that years of experience in the construction industry influence perceptions of some factors related to trust within VPTs. Specifically, there are significant differences between different experience levels regarding organizational training, team leader selection and collaborative work environments.

Compared to practitioners with 5-10 years of experience or less than 5 years, participants with more than 10 years of industry experience consistently focused on organizational training. A significant difference was observed between the group with 5-10 years of experience and the group with more than 10 years of experience. This suggests that more seasoned professionals may have a deeper appreciation for the role

of structured training in facilitating virtual collaboration and trust-building, particularly as they are likely more involved in team leadership and talent development responsibilities (Badrinarayanan, 2024; Pereira et al., 2024). A similar pattern emerged for the selection of team leaders. Again, the most experienced group perceived this factor as substantially more critical, whereas respondents with fewer years of experience assigned lower importance to it (Liu & Huang, 2022; Mutha & Srivastava, 2023; Swart et al., 2022). The Mann-Whitney U test revealed a significant difference between the 5-10 year and more than 10-year groups, as shown in Table 16 and Table 17. This disparity may stem from the more experienced respondents' awareness of the long-term impact that leadership quality has on VPT dynamics, trust development, and performance consistency (Garro-Abarca et al., 2021; Liu & Huang, 2022). Additionally, collocation environment, a key project team-related factor, was also rated significantly higher by respondents with more than 10 years of experience, while those with 5 to 10 years rated it the lowest. The statistical difference between these two groups suggests that professionals with extensive industry backgrounds are more likely to recognize the importance of physical or simulated co-presence (such as through VR platforms) in enhancing trust and collaboration in virtual settings (Cheng et al., 2021; Steinicke et al., 2020). It may also reflect generational differences in expectations for interpersonal familiarity and team synergy, which traditionally emerged through in-person interactions (Singh et al., 2022; Wei et al., 2024).

Table 16 *Results of the Mann-Whitney U Test of Trust Influencing Factors for Respondents' Experience in Construction Industry*

Factors	<5 years vs 5 to 10 years	<5 years vs >10 years	5 to 10 years vs >10 years
Organizational training	0.331	0.781	0.032*
Selection of team leaders	0.724	0.668	0.011*
Collocation environment	0.087	0.253	0.021*

*Significant at p-value <0.05

Table 17 *Results of the Mean and Rank of Trust Factors with Perceived Differences for Respondents' Experience in Construction Industry*

Factors	Years of Experience in Construction Industry	Median	Mean	Ranking within Experience Category
Organizational training	<5 years	5.0	4.74	4
	5 to 10 years	5.0	4.38	9
	>10 years	6.0	5.70	1
Selection of team leaders	<5 years	5.0	4.65	6
	5 to 10 years	4.0	4.51	7
	>10 years	6.0	5.65	2
Collocation environment	<5 years	5.0	4.93	5
	5 to 10 years	4.0	4.24	11
	>10 years	6.0	5.39	7

These results collectively underscore industry experience in forming individuals' opinions regarding factors contributing to trust in virtual worlds. More experienced practitioners are able to take into consideration structural and relational factors contributing to trust, including factors of training, leadership choices and situational closeness, whereas less experienced ones are more focused on functional fulfillment of tasks or superficial contact of interaction (Sagar et al., 2021; Zaharie, 2021). These outcomes imply the demand

for specialized management and supporting measures corresponding to the experiential profiles of VPT members.

Besides findings for trust-related variables, this study also obtained perceived variations in essential technological competency factors among respondents who differed in industry experience. That is, flexibility and team leadership, as individual traits, significantly differed in perceived importance in respondents' experience in terms of years.

Respondents with over 10 years of experience highly value team leadership as a personal quality, compared to moderate values from those with less than 5 and 5 to 10 years' experience, respectively. The use of Mann-Whitney U tests confirmed substantial differences between most experienced and two groups with lower experience, shown in Table 18 and Table 19. These results suggest that experienced professionals demonstrate a greater perceptiveness of distributed leadership in digital settings, where hierarchical oversight is oftentimes limited and peer-driven coordination is instrumental in ensuring project success in such settings (Cripe & Burleigh, 2022; Hincapie & Costa, 2024; Kashive et al., 2022; Pereira et al., 2024). Their greater level of experience may enhance their sensitivity to nuances in leadership of digitally connected teams, thus assigning greater importance to leadership abilities in digital settings (Ben Sedrine et al., 2021; Kohntopp & McCann, 2020). As a second personal quality, flexibility, as a potential to adapt to dynamic demands, time zones and unpredictable obstacles, was viewed differentially in reference to levels of experience. While highly valued in every group, it is particularly critical in respondents with over 10 years' experience, significantly higher than those who had 5 to 10 years' experience. The significant statistical variation found indicates that greater levels of experience align respondents to view flexibility as a behavioral enabler in addition to a technical ability of virtual project teams (Lindeblad et al., 2016; Walsh, 2019). Their longer experiences in greater diversity of project settings and digital evolution may clarify their higher value in flexibility as a core ability in digital collaboration (Lim et al., 2011; Walsh, 2019).

Table 18 *Results of the Mann-Whitney U Test of Technological Competency for Respondents' Experience in Construction Industry*

Factors	<5 years vs 5 to 10 years	<5 years vs >10 years	5 to 10 years vs >10 years
Team leadership	0.299	0.031*	0.006*
Flexibility	0.274	0.084	0.006*

*Significant at p-value <0.05

Table 19 *Results of the Mean and Rank of Technological Competency Factors with Perceived Differences for Respondents' Experience in Construction Industry*

Factors	Years of Experience in Construction Industry	Median	Mean	Ranking within Experience Category
Team leadership	<5 years	5.0	5.07	3
	5 to 10 years	5.0	4.68	5
	>10 years	6.0	5.87	1
Flexibility	<5 years	5.0	5.25	1
	5 to 10 years	5.0	5.03	2
	>10 years	6.0	5.87	1

Collectively, these findings underscore the insight that professional experience in the construction sector not only shapes perceptions of trust-building mechanisms but also influences perceptions of the necessity of specific technological competency. Experienced practitioners often consider leadership and adaptability to be indispensable assets for dealing with complex virtual environments, while those with less experience may focus more on specific skills or techniques (Mirfardi, 2011). These insights have important

implications for the formulation of specific capacity development strategies and help customize approaches to managing virtual project teams according to the experience profiles of team members.

Conclusion

As VPTs become increasingly important as indispensable elements of project delivery in the built environment sector, it has become necessary to understand how different professional roles and individual backgrounds influence perceptions of trust and technological competency in virtual contexts. This study aims to examine how participants with different characteristics assess the importance of factors affecting trust and technological competency within VPTs.

The results revealed significant differences in perceived importance among respondents, based on respondents' designations, ages, educational backgrounds and levels of experience in VPTs within the built environment sector. First, the different designations show a clear focus on OCB and organizing and planning capabilities, highlighting differences in operational focus and cross-functional collaboration priorities. For instance, as a result of differences in job responsibilities and content, Architects and Construction Managers placed significantly higher importance on OCB and planning competencies compared to Project Managers and other roles. In terms of age, both the youngest and oldest participants rated commitment and benevolence more highly than mid-career professionals, suggesting a U-shaped pattern in how interpersonal trust factors are valued. Gender was not found to significantly influence the perceived importance of any factor, indicating a broad alignment in trust and competency expectations across male and female respondents. Education background affected perceptions of both managerial support and proactive behaviour, which suggests that respondents with bachelor's or postgraduate degrees rated senior management support and information seeking more highly than those with lower qualifications. Years of construction industry experience also mattered, and more experienced professionals placed greater emphasis on formal training, leader selection and team proximity. Furthermore, team leadership and flexibility of personal characteristics showed the same trend of variation among respondents with different industry experience.

While this study was successful in achieving its objectives, its cross-sectional design and reliance on self-reported data may have introduced perceptual biases that limited the study. Future research should employ longitudinal or mixed-method approaches to explore how these perceptions evolve over time and how they influence actual team performance. Furthermore, while the relatively small sample size of this study is appropriate for research within Singapore's built environment industry, it has limitations when generalizing findings to other countries, regions and cultures. Future research could expand the sample size and collect data from respondents with diverse backgrounds to broaden the scope of findings.

Despite the limitations, this study contributes to the literature by offering a nuanced, multi-dimensional perspective on trust and technological competency in VPTs. Unlike previous studies that treat these constructs as static, this study demonstrates how perceptions of importance evolve with experience, education, and professional role. From a practical perspective, the findings suggest that one-size-fits-all training or trust-building interventions may be ineffective. Instead, organizations should develop targeted programs that reflect role-specific tasks, generational preferences, and levels of digital exposure. For instance, early-career professionals may benefit from basic trust-building and tool adoption guidance, while experienced team members may require support in strategic leadership and coordination across distributed settings. Educational background should also be considered, especially when designing learning modules focused on proactive digital behavior or managerial alignment. Ultimately, understanding these perceptual differences can help organizations improve collaboration, optimize team design and strengthen project delivery in virtual environments.

Acknowledgment

This work was supported by the Singapore Ministry of Education Academic Research Fund TIER 1 [A-0008553-01-00].

AI Tool Declaration

In this article, we used Grammarly for the purpose of language editing and grammar correction.

Reference

Ale Ebrahim, N., Ahmed, S., & Taha, Z. (2009). Virtual teams: A literature review. *Australian journal of basic and applied sciences*, *3*(3), 2653-2669.

Alsharo, M., Gregg, D., & Ramirez, R. (2017). Virtual team effectiveness: The role of knowledge sharing and trust. *INFORMATION & MANAGEMENT*, *54*(4), 479-490. https://doi.org/https://doi.org/10.1016/j.im.2016.10.005

Alvarenga, J. C., Branco, R. R., Guedes, A. L. A., Soares, C. A. P., & e Silva, W. d. S. (2019). The project manager core competencies to project success. *International Journal of Managing Projects in Business*.

Assaad, R., & El-adaway, I. H. (2021). Guidelines for Responding to COVID-19 Pandemic: Best Practices, Impacts, and Future Research Directions. *Journal of Management in Engineering*, *37*(3), 06021001. https://doi.org/doi:10.1061/(ASCE)ME.1943-5479.0000906

Badrinarayanan, V. (2024). Trust building strategies for virtual leaders in the post pandemic era [Article]. *Project Leadership and Society*, *5*, Article 100126. https://doi.org/10.1016/j.plas.2024.100126

Baker, S. R., Bloom, N., Davis, S. J., & Terry, S. J. (2020). *Covid-induced economic uncertainty*.

Barber, B. (1983). The logic and limits of trust.

Bell, B. S., & Kozlowski, S. W. J. (2002). A Typology of Virtual Teams:Implications for Effective Leadership. *Group & Organization Management*, *27*(1), 14-49. https://doi.org/10.1177/1059601102027001003

Ben Sedrine, S., Bouderbala, A., & Nasraoui, H. (2021). Leadership style effect on virtual team efficiency: trust, operational cohesion and media richness roles. *Journal of Management Development*, *40*(5), 365-388. https://doi.org/10.1108/JMD-10-2018-0289

Breuer, C., Hüffmeier, J., & Hertel, G. (2016). Does trust matter more in virtual teams? A meta-analysis of trust and team effectiveness considering virtuality and documentation as moderators. *Journal of Applied Psychology*, *101*, 1151-1177. https://doi.org/10.1037/apl0000113

Breuer, C., Hüffmeier, J., Hibben, F., & Hertel, G. (2020). Trust in teams: A taxonomy of perceived trustworthiness factors and risk-taking behaviors in face-to-face and virtual teams [Article]. *Human Relations*, *73*(1), 3-34. https://doi.org/10.1177/0018726718818721

Brill, J. M., Bishop, M., & Walker, A. E. (2006). The competencies and characteristics required of an effective project manager: A web-based Delphi study. *Educational technology research and development*, *54*(2), 115-140.

Burcin Becerik-Gerber, A. M. A., Ku, K., & Jazizadeh, F. (2012). BIM-Enabled Virtual and Collaborative Construction Engineering and Management. *Journal of Professional Issues in Engineering Education and Practice*, *138*(3), 234-245. https://doi.org/doi:10.1061/(ASCE)EI.1943-5541.0000098

Burke, C. S., Sims, D. E., Lazzara, E. H., & Salas, E. (2007). Trust in leadership: A multi-level review and integration. *The Leadership Quarterly*, *18*(6), 606-632. https://doi.org/https://doi.org/10.1016/j.leaqua.2007.09.006

Carrier, L. M., Spradlin, A., Bunce, J. P., & Rosen, L. D. (2015). Virtual empathy: Positive and negative impacts of going online upon empathy in young adults. *Computers in Human Behavior*, *52*, 39-48. https://doi.org/https://doi.org/10.1016/j.chb.2015.05.026

Cheng, X., Bao, Y., Yu, X., & Shen, Y. (2021). Trust and Group Efficiency in Multinational Virtual Team Collaboration: A Longitudinal Study [Article]. *Group Decision and Negotiation*, *30*(3), 529-551. https://doi.org/10.1007/s10726-020-09722-x

Chinowsky, P. S., & Rojas, E. M. (2003). Virtual Teams: Guide to Successful Implementation. *Journal of Management in Engineering*, *19*(3), 98-106. https://doi.org/doi:10.1061/(ASCE)0742-597X(2003)19:3(98)

Colbert, A. E., Bono, J. E., & Purvanova, R. K. (2016). Flourishing via workplace relationships: Moving beyond instrumental support. *Academy of Management Journal*, *59*(4), 1199-1223.

Cook, J., & Wall, T. (1980). New work attitude measures of trust, organizational commitment and personal need non-fulfilment. *Journal of occupational psychology*, *53*(1), 39-52.

https://doi.org/https://doi.org/10.1111/j.2044-8325.1980.tb00005.x
Creasy, T., & Anantatmula, V. S. (2013). From every direction—How personality traits and dimensions of project managers can conceptually affect project success. *Project Management Journal*, *44*(6), 36-51.
Cripe, K. M., & Burleigh, C. (2022). Examining leadership skills, behaviors, and effective communication for virtual IT project managers [Article]. *Team Performance Management*, *28*(3-4), 223-237. https://doi.org/10.1108/TPM-11-2021-0085
Cruz-Jesus, F., Vicente, M. R., Bacao, F., & Oliveira, T. (2016). The education-related digital divide: An analysis for the EU-28. *Computers in Human Behavior*, *56*, 72-82.
Darban, M. (2023). The future of virtual team learning: navigating the intersection of AI and education [Article]. *Journal of Research on Technology in Education*. https://doi.org/10.1080/15391523.2023.2288912
Dewa, L. H., Lavelle, M., Pickles, K., Kalorkoti, C., Jaques, J., Pappa, S., & Aylin, P. (2019). Young adults' perceptions of using wearables, social media and other technologies to detect worsening mental health: A qualitative study [Article]. *Plos one*, *14*(9), Article e0222655. https://doi.org/10.1371/journal.pone.0222655
Ehrhart, M. G., & Naumann, S. E. (2004). Organizational citizenship behavior in work groups: a group norms approach. *Journal of Applied Psychology*, *89*(6), 960.
Elena-Bucea, A., Cruz-Jesus, F., Oliveira, T., & Coelho, P. S. (2021). Assessing the role of age, education, gender and income on the digital divide: Evidence for the European Union. *Information Systems Frontiers*, *23*, 1007-1021.
Faqih, K. M. S. (2022). Internet shopping in the Covid-19 era: Investigating the role of perceived risk, anxiety, gender, culture, and trust in the consumers' purchasing behavior from a developing country context. *Technology in Society*, *70*, 101992. https://doi.org/https://doi.org/10.1016/j.techsoc.2022.101992
Fekry Youssef, M., Fathy Eid, A., & Mohamed Khodeir, L. (2023). Challenges affecting efficient management of virtual teams in construction in times of the COVID-19 pandemic. *Ain Shams Engineering Journal*, *14*(7), 102008. https://doi.org/https://doi.org/10.1016/j.asej.2022.102008
Flak, O., & Pyszka, A. (2022). Evolution from human virtual teams to artificial virtual teams supported by artificial intelligence. Results of literature analysis and empirical research. *Problemy Zarządzania*, *20*(2/2022 (96)), 48-69.
Flavian, C., Guinalíu, M., & Jordan, P. (2019). Antecedents and consequences of trust on a virtual team leader. *European Journal of Management and Business Economics*, *28*(1), 2-24. https://doi.org/10.1108/EJMBE-11-2017-0043
Flavián, C., Guinalíu, M., & Jordán, P. (2022). Virtual teams are here to stay: How personality traits, virtuality and leader gender impact trust in the leader and team commitment [Article]. *European Research on Management and Business Economics*, *28*(2), Article 100193. https://doi.org/10.1016/j.iedeen.2021.100193
Ford, R. C., Piccolo, R. F., & Ford, L. R. (2017). Strategies for building effective virtual teams: Trust is key [Article]. *Business Horizons*, *60*(1), 25-34. https://doi.org/10.1016/j.bushor.2016.08.009
Fryrear, A. (2015). What's a good survey response rate. *Survey Gizmo*.
Furumo, K., & Pearson, J. M. (2007). Gender-based communication styles, trust, and satisfaction in virtual teams. *Journal of Information, Information Technology & Organizations*, *2*.
Galanti, T., Ferrara, B., Benevene, P., & Buonomo, I. (2023). Rethinking the Unthinkable: A Delphi Study on Remote Work during COVID-19 Pandemic [Article]. *Social Sciences*, *12*(9), Article 497. https://doi.org/10.3390/socsci12090497
Garro-Abarca, V., Palos-Sanchez, P., & Aguayo-Camacho, M. (2021). Virtual Teams in Times of Pandemic: Factors That Influence Performance [Original Research]. *Frontiers in Psychology*, *12*. https://doi.org/10.3389/fpsyg.2021.624637
Germain, M. L., & McGuire, D. (2014). The Role of Swift Trust in Virtual Teams and Implications for Human Resource Development [Article]. *Advances in Developing Human Resources*, *16*(3), 356-370. https://doi.org/10.1177/1523422314532097

Grant, A. M., & Ashford, S. J. (2008). The dynamics of proactivity at work. *Research in Organizational Behavior*, *28*, 3-34. https://doi.org/https://doi.org/10.1016/j.riob.2008.04.002

Hacker, J., Johnson, M., Saunders, C., & Thayer, A. L. (2019). Trust in virtual teams: A multidisciplinary review and integration [Article]. *Australasian Journal of Information Systems*, *23*, 1-36. https://doi.org/10.3127/ajis.v23i0.1757

Hacker, J. V., Johnson, M., Saunders, C., & Thayer, A. L. (2019). Trust in Virtual Teams: A Multidisciplinary Review and Integration. *Australasian Journal of Information Systems*, *23*(0). https://doi.org/10.3127/ajis.v23i0.1757

Hanusz, Z., Tarasinska, J., & Zielinski, W. (2016). Shapiro–Wilk test with known mean. *REVSTAT-statistical Journal*, *14*(1), 89–100-189–100.

Henttonen, K., & Blomqvist, K. (2005). Managing distance in a global virtual team: the evolution of trust through technology-mediated relational communication. *Strategic Change*, *14*(2), 107-119. https://doi.org/https://doi.org/10.1002/jsc.714

Hertel, G., Geister, S., & Konradt, U. (2005). Managing virtual teams: A review of current empirical research. *Human Resource Management Review*, *15*(1), 69-95. https://doi.org/https://doi.org/10.1016/j.hrmr.2005.01.002

Hincapie, M. X., & Costa, P. (2024). Fostering hybrid team performance through inclusive leadership strategies [Article]. *ORGANIZATIONAL DYNAMICS*, *53*(3), Article 101072. https://doi.org/10.1016/j.orgdyn.2024.101072

Holste, J. S., & Fields, D. (2010). Trust and tacit knowledge sharing and use. *Journal of knowledge management*, *14*(1), 128-140.

Hooghe, M., Marien, S., & De Vroome, T. (2012). The cognitive basis of trust. The relation between education, cognitive ability, and generalized and political trust. *Intelligence*, *40*(6), 604-613.

Hosseini, M. R., Bosch-Sijtsema, P., Arashpour, M., Chileshe, N., & Merschbrock, C. (2019). A qualitative investigation of perceived impacts of virtuality on effectiveness of hybrid construction project teams. *Construction Innovation*, *18*(1), 109-131. https://doi.org/10.1108/CI-10-2016-0052

Hudson, N. E. (2022). The Function and Dynamics of Interpersonal Trust within Workplace Learning in High Pressure Context. In: University of Chester.

Hwang, B.-G., Ngo, J., & Her, P. W. Y. (2020). Integrated Digital Delivery: Implementation status and project performance in the Singapore construction industry. *Journal of Cleaner Production*, *262*, 121396. https://doi.org/https://doi.org/10.1016/j.jclepro.2020.121396

IPMA. (2017). *Individual Competence Baseline (ICB) Version 4*. International Project Management Association.

Jarvenpaa, S. L., & Leidner, D. E. (1999). Communication and Trust in Global Virtual Teams [Article]. *Organization science*, *10*(6), 791-815. https://doi.org/10.1287/orsc.10.6.791

Jin, S. V. (2024). "In the Metaverse We (Mis)trust?" Third-Level Digital (In)equality, Social Phobia, Neo-Luddism, and Blockchain/Cryptocurrency Transparency in the Artificial Intelligence-Powered Metaverse. *Cyberpsychology, Behavior, and Social Networking*, *27*(1), 64-75. https://doi.org/10.1089/cyber.2022.0376

Joshi, A., Kale, S., Chandel, S., & Pal, D. K. (2015). Likert scale: Explored and explained. *British journal of applied science & technology*, *7*(4), 396.

Kashive, N., Khanna, V. T., & Powale, L. (2022). Virtual team performance: E-leadership roles in the era of COVID-19 [Article]. *Journal of Management Development*, *41*(5), 277-300. https://doi.org/10.1108/JMD-05-2021-0151

Kasper-Fuehrer, E. C., & Ashkanasy, N. M. (2001). Communicating trustworthiness and building trust in interorganizational virtual organizations. *Journal of Management*, *27*(3), 235-254. https://doi.org/https://doi.org/10.1016/S0149-2063(01)00090-3

Kaur, S., Arif, M., & Akre, V. (2016). Effect of Social Media on Trust in Virtual Project Teams of Construction Sector in Middle East. In Y. K. Dwivedi, M. Mantymaki, M. N. Ravishankar, M. Janssen, M. Clement, E. L. Slade, N. P. Rana, S. Alsharhan, & A. C. Simintiras (Eds.), *Social Media: The Good, the Bad, and the Ugly* (Vol. 9844, pp. 419-429). 15th International-Federation-of-Information-Processing (IFIP)

WG 6.11 Conference on e-Business, e-Services, and e-Society (I3E).
Kiffin-Petersen, S., Murphy, S. A., & Soutar, G. (2012). The problem-solving service worker: Appraisal mechanisms and positive affective experiences during customer interactions. *Human Relations*, *65*(9), 1179-1206.
Kimble, C. (2011). Building effective virtual teams: How to overcome the problems of trust and identity in virtual teams. *Global Business and Organizational Excellence*, *30*(2), 6-15. https://doi.org/https://doi.org/10.1002/joe.20364
Kohntopp, T., & McCann, J. (2020). Leadership in Virtual Organizations: Influence on Workplace Engagement. In S. Dhiman (Ed.), *The Palgrave Handbook of Workplace Well-Being* (pp. 1-26). Springer International Publishing. https://doi.org/10.1007/978-3-030-02470-3_12-1
Krebs, S. A., Hobman, E. V., & Bordia, P. (2006). Virtual teams and group member dissimilarity: Consequences for the development of trust [Article]. *Small group research*, *37*(6), 721-741. https://doi.org/10.1177/1046496406294886
Kunkcu, H., Koc, K., & Gurgun, A. P. (2025). Exploring the Patterns Shaping Communication in the Turkish Construction Industry. *Journal of Management in Engineering*, *41*(1), 04024063. https://doi.org/doi:10.1061/JMENEA.MEENG-6375
Lewicki, R. J., Tomlinson, E. C., & Gillespie, N. (2006). Models of Interpersonal Trust Development: Theoretical Approaches, Empirical Evidence, and Future Directions. *Journal of Management*, *32*(6), 991-1022. https://doi.org/10.1177/0149206306294405
Liao, L., & Teo, E. A. L. (2019). Managing critical drivers for building information modelling implementation in the Singapore construction industry: an organizational change perspective. *International Journal of Construction Management*, *19*(3), 240-256. https://doi.org/10.1080/15623599.2017.1423165
Lim, B. T., Ling, F. Y., Ibbs, C. W., Raphael, B., & Ofori, G. (2011). Empirical analysis of the determinants of organizational flexibility in the construction business. *Journal of construction engineering and management*, *137*(3), 225-237.
Limsila, K., & Ogunlana, S. O. (2008). Performance and leadership outcome correlates of leadership styles and subordinate commitment. *Engineering, Construction and Architectural Management*, *15*(2), 164-184. https://doi.org/10.1108/09699980810852682
Lindeblad, P. A., Voytenko, Y., Mont, O., & Arnfalk, P. (2016). Organisational effects of virtual meetings. *Journal of Cleaner Production*, *123*, 113-123. https://doi.org/https://doi.org/10.1016/j.jclepro.2015.08.058
Liu, R., & Huang, Z. (2022). Is participatory leadership conducive to the construction of virtual teams? Based on multi-agent simulation model [Article]. *Frontiers in Psychology*, *13*, Article 1010007. https://doi.org/10.3389/fpsyg.2022.1010007
Lythreatis, S., Singh, S. K., & El-Kassar, A.-N. (2022). The digital divide: A review and future research agenda. *Technological Forecasting and Social Change*, *175*, 121359.
Malhotra, Y. (2000). *Knowledge management and virtual organizations*. IGI global.
Marlow, S. L., Lacerenza, C. N., & Salas, E. (2017). Communication in virtual teams: a conceptual framework and research agenda. *Human Resource Management Review*, *27*(4), 575-589. https://doi.org/https://doi.org/10.1016/j.hrmr.2016.12.005
Mayer, R. C., Davis, J. H., & Schoorman, F. D. (1995). An Integrative Model of Organizational Trust. *ACADEMY OF MANAGEMENT REVIEW*, *20*(3), 709-734.
Maznevski, M. L., & Chudoba, K. M. (2000). Bridging space over time: Global virtual team dynamics and effectiveness. *Organization science*, *11*(5), 473-492. https://doi.org/10.1287/orsc.11.5.473.15200
McAllister, D. J. (1995). Affect- and Cognition-Based Trust as Foundations for Interpersonal Cooperation in Organizations. *Academy of Management Journal*, *38*(1), 24-59. https://doi.org/10.5465/256727
McKight, P. E., & Najab, J. (2010). Kruskal-wallis test. *The corsini encyclopedia of psychology*, 1-1.
Mirfardi, A. (2011). Trust and its relationship to demographic factors. *Journal of Social Sciences*, *7*(2), 168-174.
Moradi, S., Kähkönen, K., Klakegg, O. J., & Aaltonen, K. (2021). A Competency Model for the Selection and Performance Improvement of Project Managers in Collaborative Construction Projects: Behavioral

Studies in Norway and Finland. *Buildings*, *11*(1), 4. https://www.mdpi.com/2075-5309/11/1/4

Morley, S., Cormican, K., & Folan, P. (2015). An Analysis of Virtual Team Characteristics: A Model for Virtual Project Managers. *Journal of technology management & innovation*, *10*(1), 188-203. https://doi.org/10.4067/s0718-27242015000100014

Mutha, P., & Srivastava, M. (2023). Decoding leadership to leverage employee engagement in virtual teams [Article]. *International Journal of Organizational Analysis*, *31*(3), 737-758. https://doi.org/10.1108/IJOA-07-2021-2856

Nachar, N. (2008). The Mann-Whitney U: A test for assessing whether two independent samples come from the same distribution. *Tutorials in quantitative Methods for Psychology*, *4*(1), 13-20.

Ngo, J., & Hwang, B.-G. (2022). Critical Project Management Knowledge and Skills for Managing Projects with Smart Technologies. *Journal of Management in Engineering*, *38*(6), 05022013. https://doi.org/doi:10.1061/(ASCE)ME.1943-5479.0001095

Nwaogu, J. M., Chan, A. P. C., & Naslund, J. A. (2022). Measures to Improve the Mental Health of Construction Personnel Based on Expert Opinions. *Journal of Management in Engineering*, *38*(4), 04022019. https://doi.org/doi:10.1061/(ASCE)ME.1943-5479.0001045

Panteli, N., & Tucker, R. (2009). Power and trust in global virtual teams [Article]. *Communications of the ACM*, *52*(12), 113-115. https://doi.org/10.1145/1610252.1610282

Paton, S., & Hodgson, D. (2016). Project managers on the edge: Liminality and identity in the management of technical work. *New Technology, Work and Employment*, *31*(1), 26-40.

Paul, J., Menzies, J., Zutshi, A., & Cai, H. (2020). New and novel business paradigms in and from China and India. *European Business Review*, *32*(5), 758-800. https://doi.org/10.1108/EBR-09-2020-0224

Pereira, L., Jerónimo, C., Simões, F., Dias, Á., da Costa, R. L., & Gonçalves, R. (2024). Project virtual teams: systematic literature review [Article]. *International Journal of Agile Systems and Management*, *17*(1), 15-45. https://doi.org/10.1504/IJASM.2024.135370

Pinjani, P., & Palvia, P. (2013). Trust and knowledge sharing in diverse global virtual teams [Article]. *Information and Management*, *50*(4), 144-153. https://doi.org/10.1016/j.im.2012.10.002

PMI. (2017). *A Guide to the Project Management Body of Knowledge*. Project Management Institute.

Rezgui, Y. (2007). Exploring virtual team-working effectiveness in the construction sector. *Interacting with Computers*, *19*(1), 96-112. https://doi.org/https://doi.org/10.1016/j.intcom.2006.07.002

Robert Jr, L., Denis, A., & Hung, Y. T. (2009). Individual swift trust and knowledge-based trust in face-to-face and virtual team members [Article]. *JOURNAL OF MANAGEMENT INFORMATION SYSTEMS*, *26*(2), 241-279. https://doi.org/10.2753/MIS0742-1222260210

Sagar, S. K., Arif, M., Oladinrin, O. T., & Rana, M. Q. (2021). Exploring factors affecting trust in construction virtual project teams. *10*, 11. http://hdl.handle.net/2436/624518

Sagar, S. K., Oladinrin, O. T., Arif, M., & Rana, M. Q. (2023). Interpretive structural model of trust factors in construction virtual project teams [Article]. *Construction Innovation*, *23*(1), 248-264. https://doi.org/10.1108/CI-09-2021-0179

Schein, E. H. (2010). *Organizational culture and leadership* (Vol. 2). John Wiley & Sons.

Schiller, S. Z., & Mandviwalla, M. (2007). Virtual Team Research:An Analysis of Theory Use and a Framework for Theory Appropriation. *Small group research*, *38*(1), 12-59. https://doi.org/10.1177/1046496406297035

Singh, H., Cascini, G., & McComb, C. (2022). Virtual and Face-to-Face Team Collaboration Comparison Through an Agent-Based Simulation [Article]. *Journal of Mechanical Design*, *144*(7), Article 071706. https://doi.org/10.1115/1.4054242

Spencer, L. M., & Spencer, P. S. M. (1993). *Competence at Work models for superior performance*. John Wiley & Sons.

Stahl, G. K., Maznevski, M. L., Voigt, A., & Jonsen, K. (2010). Unraveling the effects of cultural diversity in teams: A meta-analysis of research on multicultural work groups. *Journal of international business studies*, *41*, 690-709.

Stahl, G. K., & Tung, R. L. (2015). Towards a more balanced treatment of culture in international business studies: The need for positive cross-cultural scholarship. *Journal of international business studies*,

46, 391-414.

Staples, D. S., & Webster, J. (2008). Exploring the effects of trust, task interdependence and virtualness on knowledge sharing in teams [Article]. *INFORMATION SYSTEMS JOURNAL*, *18*(6), 617-640. https://doi.org/10.1111/j.1365-2575.2007.00244.x

Steinicke, F., Lehmann-Willenbrock, N., & Meinecke, A. L. (2020). *A First Pilot Study to Compare Virtual Group Meetings using Video Conferences and (Immersive) Virtual Reality* Proceedings of the 2020 ACM Symposium on Spatial User Interaction, Virtual Event, Canada. https://doi.org/10.1145/3385959.3422699

Stewart, K. J., & Gosain, S. (2006). The impact of ideology on effectiveness in open source software development teams [Article]. *MIS Quarterly: Management Information Systems*, *30*(2), 291-314. https://doi.org/10.2307/25148732

Sun, L., Fukuda, T., & Resch, B. (2014). A synchronous distributed cloud-based virtual reality meeting system for architectural and urban design. *Frontiers of Architectural Research*, *3*(4), 348-357. https://doi.org/https://doi.org/10.1016/j.foar.2014.05.001

Swart, K., Bond-Barnard, T., & Chugh, R. (2022). Challenges and critical success factors of digital communication, collaboration and knowledge sharing in project management virtual teams: a review [Article]. *International Journal of Information Systems and Project Management*, *10*(4), 59-75. https://doi.org/10.12821/ijispm100404

Tavakol, M., & Dennick, R. (2011). Making sense of Cronbach's alpha. *Int J Med Educ*, *2*, 53-55. https://doi.org/10.5116/ijme.4dfb.8dfd

Teo, E. A. L., Chan, S. L., & Tan, P. H. (2007). Empirical Investigation into Factors Affecting Exporting Construction Services in SMEs in Singapore. *Journal of construction engineering and management*, *133*(8), 582-591. https://doi.org/doi:10.1061/(ASCE)0733-9364(2007)133:8(582)

Tucker, C., Olsen, B., & Hale, R. T. (2023). Trust and commitment: a comparative study of virtual team communication across industries [Article]. *Team Performance Management*, *29*(1-2), 152-165. https://doi.org/10.1108/TPM-04-2022-0032

Van Laar, E., Van Deursen, A. J., Van Dijk, J. A., & De Haan, J. (2017). The relation between 21st-century skills and digital skills: A systematic literature review. *Computers in Human Behavior*, *72*, 577-588.

Voogt, J., & Roblin, N. P. (2012). A comparative analysis of international frameworks for 21st century competences: Implications for national curriculum policies. *Journal of curriculum studies*, *44*(3), 299-321.

Vukomanović, M., Young, M., & Huynink, S. (2016). IPMA ICB 4.0—A global standard for project, programme and portfolio management competences. *International journal of project management*, *34*(8), 1703-1705.

Walsh, T. (2019). Virtual Team Success with the Power of Technology Advancements. In P. A. Gordon & J. A. Overbey (Eds.), *Advances in the Technology of Managing People: Contemporary Issues in Business* (pp. 99-107). Emerald Publishing Limited. https://doi.org/10.1108/978-1-78973-073-920191009

Watanuki, H. M., & de Oliveira Moraes, R. (2022). Team Dispersion, Emergent States, and Performance in Virtual IT Service Provisioning Teams [Article]. *International Journal of Information Systems in the Service Sector*, *14*(1), Article 77. https://doi.org/10.4018/IJISSS.287577

Watanuki, H. M., & Moraes, R. d. O. (2022). Trust in virtual teams: A systematic review of information systems literature. *JISTEM-Journal of Information Systems and Technology Management*, *19*, e202219006.

Wei, F., Hwang, B.-G., Zhu, H., & Ngo, J. (2023). Project management for sustainable development: Critical determinants of technological competency for project managers with smart technologies. *Sustainable Development*, *n/a*(n/a). https://doi.org/https://doi.org/10.1002/sd.2869

Wei, F., Hwang, B. G., Zainal, N. S. B., & Zhu, H. (2024). Trust, Team Effectiveness, and Strategies: A Comparative Study between Virtual and Face-to-Face Teams [Article]. *Journal of construction engineering and management*, *150*(7), Article 04024065. https://doi.org/10.1061/JCEMD4.COENG-14522

Williams, M. (2001). In whom we trust: Group membership as an affective context for trust development.

ACADEMY OF MANAGEMENT REVIEW, *26*(3), 377-396.

Wong, Y., Shi, Y., & Wilson, D. (2004). Experience, gender composition, social presence, decision process satisfaction and group performance. Winter International Symposium on Information and Communication Technologies,

Woolley, A. W., Gupta, P., & Glikson, E. (2023). Using AI to enhance collective intelligence in virtual teams: Augmenting cognition with technology to help teams adapt to complexity. In *Handbook of virtual work* (pp. 67-88). Edward Elgar Publishing.

Woolson, R. F. (2005). Wilcoxon signed-rank test. *Encyclopedia of biostatistics*, *8*.

Zaccaro, S. J., & Bader, P. (2003). E-Leadership and the challenges of leading E-teams: Minimizing the bad and maximizing the good. *ORGANIZATIONAL DYNAMICS*, *31*(4), 377-387. https://doi.org/10.1016/S0090-2616(02)00129-8

Zaccaro, S. J., Rittman, A. L., & Marks, M. A. (2001). Team leadership. *The Leadership Quarterly*, *12*(4), 451-483. https://doi.org/https://doi.org/10.1016/S1048-9843(01)00093-5

Zaharie, M. (2021). Challenges, trust and performance in virtual teams: examining the role of openness to experience and preference for virtual teams [Article]. *Team Performance Management*, *27*(3-4), 210-228. https://doi.org/10.1108/TPM-07-2020-0066

Zheng, J., Feng, C., Xie, H., Zhao, X., & Wu, G. (2023). Ambidextrous Leadership and Innovative Behaviors in Construction Projects: Dual-Edged Sword Effects and Social Information Processing Perspective. *Journal of Management in Engineering*, *39*(1), 04022070. https://doi.org/doi:10.1061/(ASCE)ME.1943-5479.0001104

Zhu, H., Hwang, B.-G., Ngo, J., & Tan, J. P. S. (2022). Applications of Smart Technologies in Construction Project Management. *Journal of construction engineering and management*, *148*(4), 04022010. https://doi.org/doi:10.1061/(ASCE)CO.1943-7862.0002260

Zuofa, T., & Ochieng, E. G. (2021). Investigating Barriers to Project Delivery using Virtual Teams. *Procedia Computer Science*, *181*, 1083-1088. https://doi.org/https://doi.org/10.1016/j.procs.2021.01.304