Leading in the Digital Era: How Competencies, Knowledge Sharing, and Happiness Drive Virtual Team Effectiveness

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This study explores how digital leadership competencies (DLCs) affect virtual team effectiveness (VTE), highlighting the mediating roles of knowledge sharing and workplace happiness. Using data from 191 employees in Saudi Arabia and PLS-SEM, IPMA, and NCA analyses, the findings show that DLCs—like digital communication, trust, and engagement—boost VTE directly and indirectly. Results reveal that cognitive (knowledge sharing) and emotional (happiness) mechanisms both play key roles. The study offers an integrated model grounded in Social Exchange Theory and provides practical insights for developing leadership skills to enhance collaboration and well-being in digital work environments.

Keywords: digital leader, competencies, virtual team, knowledge sharing, happiness at work, social exchange theory

INTRODUCTION

In today's digital era, organizational dynamics are undergoing significant transformation, with virtual teams emerging as a key component of global business strategies (Fang et al., 2014; Hoch & Kozlowski, 2014; Kashive et al., 2022). The COVID-19 pandemic accelerated this shift, making remote work a fundamental aspect of modern organizational design (Venkatesh, 2020). By 2028, it is projected that approximately 73% of teams will include remote workers (Pattnaik & Jena, 2020). However, transitioning from traditional co-located teams to virtual teams presents a unique set of challenges, including maintaining engagement, fostering collaboration, and ensuring effective knowledge sharing in the absence of physical interaction (Avolio et al., 2014; Garro-Abarca et al., 2021).

Despite the growing reliance on virtual teams, there remains a significant gap in understanding how digital leadership competencies (DLCs) contribute to virtual team effectiveness (VTE; López-Figueroa et al., 2025). While previous studies have examined leadership's role in virtual teams (Lepsinger & DeRosa, 2010), few have focused on the specific digital leadership competencies—such as e-communication, e-social, e-trust, e-tech, e-change, and e-team—and their influence on performance outcomes (Roman et al.,

2019). Most existing research emphasizes traditional leadership styles or general effectiveness in conventional settings, overlooking the unique demands of digital leadership in dispersed, technology-mediated environments (Archanjo de Souza et al., 2020; Hoch & Dulebohn, 2017; Malibari & Bajaba, 2022; Malibari et al. 2025; Roman et al., 2019; Yoo et al., 2020). Additionally, the mechanisms by which DLCs influence team dynamics—specifically through knowledge sharing (KSH) and happiness at work (HAW)—are insufficiently understood.

Knowledge sharing is widely recognized as a catalyst for team success (AlNuaimi et al., 2022), yet limited research explores how digital leaders foster this behavior within distributed teams, where spontaneous, informal exchanges are scarce (Fatima & Masood, 2024; Wang & Noe, 2010). While some work has explored knowledge sharing in traditional organizations (Farooq, 2018; Zhao et al., 2021), the role of digital leadership in shaping a collaborative knowledge-sharing culture in virtual environments remains underdeveloped. This study addresses that gap by identifying which digital leadership behaviors enhance knowledge-sharing practices in remote teams.

Furthermore, the role of happiness at work in virtual settings remains underexplored despite growing evidence that it positively influences engagement, trust, and cooperation (Haque, 2023; Shaik & Makhecha, 2019). Employee well-being is a key driver of organizational performance (Bellet et al., 2024). However, remote work environments pose unique psychological stressors—such as social isolation, blurred work-life boundaries, and reduced interpersonal interaction—which may undermine employee happiness. Although happiness at work has been widely studied in co-located teams, its relevance and mechanisms within virtual contexts are not yet well defined (Mo et al., 2024). Most prior studies examine workplace happiness in traditional, face-to-face environments (Tadić et al., 2015; Salas-Vallina et al., 2021), with limited insight into how digital leaders can alleviate virtual work stress through competency-based actions. This study fills this critical gap by investigating how DLCs promote knowledge sharing and employee happiness as vital mediating mechanisms of virtual team performance. It integrates a psychological and relational lens into digital leadership research, highlighting how leaders can intentionally cultivate positive emotional climates in dispersed teams (Spagnoli et al., 2020; Van Zoonen & Sivunen, 2022).

To address these gaps, this study investigates how digital leadership competencies influence virtual team effectiveness through the mediating roles of knowledge sharing and workplace happiness. Grounded in Social Exchange Theory (SET; Blau, 1964), the research posits that leaders who practice transparent communication, foster trust, and create positive virtual work climates enable a reciprocal dynamic that enhances both knowledge sharing and employee happiness—ultimately improving overall team effectiveness.

This research makes several contributions. Theoretically, it integrates the Six E-Competencies Model (Roman et al., 2019) with SET, extending leadership research by demonstrating how DLCs influence virtual team effectiveness via cognitive and emotional pathways (Soon & Salamzadeh, 2021; Wang & Wang, 2022). Empirically, it offers novel evidence from 191 employees in Saudi Arabia—contributing rare insights from a non-Western context, where cultural norms may shape leadership behavior and employee perceptions (Avolio et al., 2014). Most prior work is rooted in Western samples, so this study provides a fresh cultural lens on how digital leadership is enacted in virtual teams. Methodologically, this study is among the first in organizational research to apply both Importance-Performance Map Analysis (IPMA) and Necessary Condition Analysis (NCA), offering new analytical insights into leadership modeling in digital workplaces (Richter et al., 2020). Practically, the study provides actionable insights for business leaders, human resource professionals, and policymakers, offering strategies for developing digital leadership competencies, fostering team collaboration, and supporting employee well-being in remote work environments (Chamakiotis et al., 2021; Leonardi, 2021). By examining the interplay between DLCs, knowledge sharing, and happiness at work, this research proposes a novel framework for driving virtual team effectiveness and supporting organizations in adapting to evolving workforce dynamics in the post-pandemic era.

This paper is structured as follows: the introduction outlines the research problem, gap, and significance; the next section reviews the theoretical background and hypotheses development, followed

by the methodology, results, and discussion of findings. The paper concludes with practical implications, limitations, and suggestions for future research.

THEORY AND HYPOTHESIS DEVELOPMENT

Digital Leadership Competencies

Today's organizations are increasingly immersed in digital technologies, which drive rapid innovation cycles and add complexity to organizational operations (Tagscherer & Carbon, 2023; Yoo et al., 2012). In response to these developments, the concept of digital leadership (DL) has emerged as a critical area of focus, aiming to help leaders effectively navigate the complexities and challenges associated with digital transformation (De Araujo et al., 2021; El Sawy et al., 2020; Neubauer et al., 2017; Prince, 2018). DL is characterized by the ability to engage and empower employees using digital technology, utilizing Information and Communication Technology (ICT) to enhance organizational performance (AlAjmi, 2022; Saputra et al., 2021).

Competencies, which are combinations of expertise, skills, and capacities required for specific positions (Jordan, 2012), are vital for DL. Roman et al. (2019) identified six core competencies—e-communication, e-social, e-change management, e-team, e-tech savvy, and e-trust—that encompass the diverse roles of digital leaders in enhancing virtual team effectiveness. These competencies, displayed in Table 1, address the unique challenges posed by virtual teams, such as fostering trust, ensuring effective communication, and maintaining social connections in digital settings (Soon & Salamzadeh, 2021).

TABLE 1
DEFINITION OF THE MAJOR ELEMENTS OF THE SIX E-COMPETENCIES MODEL (ROMAN ET AL., 2019)

E-competency	Description
E-communication	"The leader has the ability to communicate via ICTs in a manner that is clear and organized, avoids errors and miscommunication, and is not excessive or detrimental to performance."
E-social	"The leader has the ability to create a positive work environment and to improve communication and collaboration through a variety of virtual communication methods."
E-change	"The leader has the ability to manage change initiatives effectively through ICTs."
E-team	"The leader has the ability to build, motivate, recognize, and hold accountable teams in virtual environments."
E-tech	"The leader is technologically savvy and remains current on relevant ICT developments and ICT security-related concerns."
E-trust	"The leader has the ability when using ICTs to create a sense of trust by being perceived as honest, consistent, and fair."

This study adopts the Six E-Competencies Model to assess the impact of DLCs on virtual team effectiveness. By integrating these competencies, we focus on building trust, transparent communication, and social connections and emphasizing unity and shared objectives—key elements for virtual team success.

Virtual Team Effectiveness

Virtual teams, defined by their reliance on digital communication across geographical distances, offer numerous benefits, such as overcoming location-based limitations and enhancing global cooperation (Dulebohn & Hoch, 2017; Tan et al., 2019). Unlike traditional teams, virtual teams consist of individuals

who rarely, if ever, meet in person and primarily communicate through electronic methods (Gilson et al., 2015; Nemiro, 2016). This reliance on digital communication makes them fundamentally different from traditional teams, requiring unique leadership competencies to manage effectively.

However, they also face challenges, such as cross-cultural communication barriers, feelings of isolation, and trust issues, which can impede their effectiveness (Cascio, 2000; Horwitz et al., 2006). Understanding these dynamics is crucial for maximizing virtual team benefits while mitigating challenges. Traditionally, team effectiveness has been evaluated using performance efficiency, member satisfaction, and reduced negative behaviors like absenteeism and turnover (Cohen & Bailey, 1997). While virtual teams differ structurally from traditional teams, they still aim to meet these objectives and ensure member satisfaction (Lin et al., 2008).

Moreover, shared mental models, trust, control structures, and communication effectiveness often influence virtual team effectiveness (Sarker et al., 2011; Xiao & Jin, 2010). Recent studies highlight the complex relationships within virtual teams, particularly the roles of feedback, trust, and communication (Handke et al., 2022; Paul et al., 2021; Wei et al., 2024). Integrating DLCs, such as the six competencies mentioned previously, is essential to managing these dynamics and enhancing team effectiveness.

Social Exchange Theory

Social Exchange Theory (SET) is a foundational framework for understanding workplace behavior and the dynamics of organizational relationships (Cropanzano & Mitchell, 2005). It posits that social interactions are driven by an exchange process in which individuals seek to maximize benefits and minimize costs. These exchanges rely on principles of reciprocity, trust, and mutual benefit, which form the basis of lasting relationships in both professional and personal contexts.

Initially rooted in sociology, psychology, and anthropology (Homans, 1958; Mauss, 1925), SET evolved through contributions like Homans (1961), who emphasized psychological motivations based on expected rewards, and Blau (1964), who highlighted the voluntary nature of social interactions grounded in anticipated reciprocity. Since then, SET has been widely applied to explain organizational phenomena such as commitment (Bishop et al., 2000), organizational citizenship behaviors (Organ, 1990), supervisor-subordinate relationships (Ladd & Henry, 2000), and perceptions of justice (Tepper & Taylor, 2003). Cropanzano et al. (2017) further assert that perceptions of fairness and trust in leaders promote stronger employee commitment and performance.

SET remains highly relevant in modern workplaces where interactions are increasingly virtual and asynchronous (Chernyak-Hai & Rabenu, 2018). The theory has expanded beyond material exchanges to include intangible resources like knowledge, emotional support, and recognition. This is particularly critical in virtual teams, where physical proximity is lacking, and leaders must foster engagement, trust, and collaboration through digital channels. Our study applies SET to examine how digital leadership competencies (DLCs)—such as communication and trust—contribute to virtual team effectiveness. We propose that leaders who engage in high-quality social exchanges foster an environment conducive to knowledge sharing and happiness at work, both essential for effective remote collaboration.

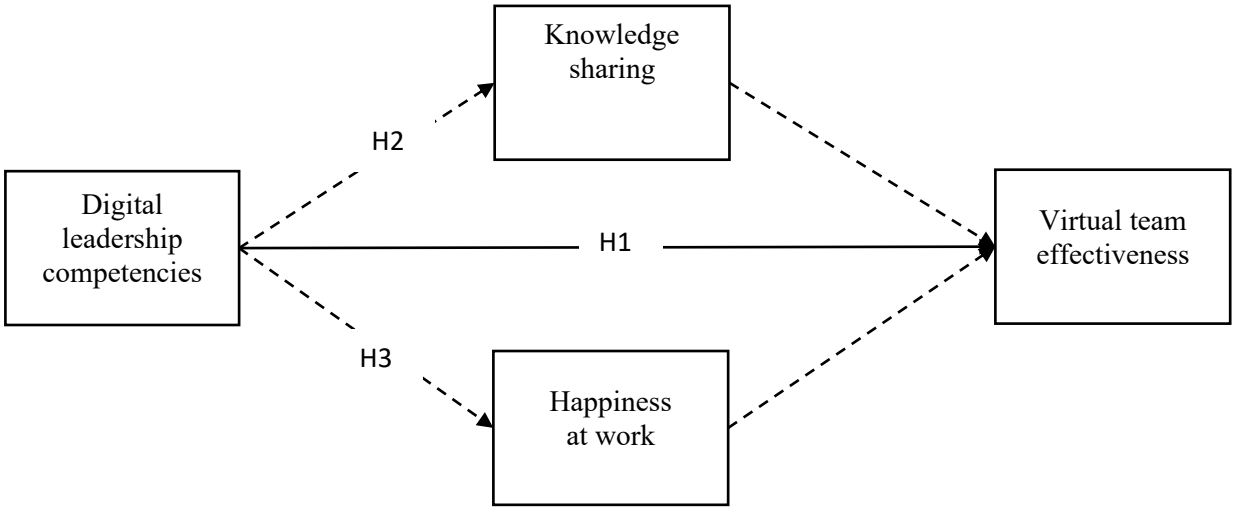
Recent studies support this theoretical direction. For instance, Luqman et al. (2023) show how SET applies in digitally mediated environments, highlighting how transparent communication and supportiveness—when delivered via digital platforms—enhance trust and reciprocity among team members. Their work underscores that virtual leadership behaviors can reinforce social exchange processes without face-to-face interaction. Similarly, Chen et al. (2018) find that leadership influenced by SET principles improves knowledge-sharing intentions. Han et al. (2019) demonstrate that responsible leadership, aligned with SET, positively affects employee motivation and performance. Colquitt et al. (2013) further support this view by highlighting how trust, commitment, and support—core dimensions of SET—positively affect employee performance and organizational outcomes. These findings collectively affirm that SET remains a robust lens for understanding digitally mediated leader-follower interactions.

Building on this foundation, we argue that SET offers a compelling explanation for how DLCs can foster virtual team effectiveness. Leaders who demonstrate fairness, consistency, and integrity in their digital interactions create trust, which reduces the risks associated with sharing knowledge and promotes a

supportive work atmosphere. This social environment, in turn, enhances both cognitive (knowledge sharing) and affective (happiness at work) dimensions of team functioning—two mechanisms critical for performance in virtual settings.

This study explores the direct relationship between DLCs and virtual team effectiveness, grounded in SET. Also, the study hypothesizes that knowledge sharing and happiness at work mediate the relationship between digital leadership competencies and virtual team effectiveness, forming a dual pathway grounded in SET (see Figure 1).

FIGURE 1
THE CONCEPTUAL RESEARCH MODELS



Digital Leadership Competencies and Virtual Team Effectiveness

The rising frequency of virtual teams places significant demands on leadership, requiring a transition from conventional leadership styles to digital leadership competencies. To lead effectively in virtual environments, leaders must develop specific skills tailored to address challenges such as communication limitations, trust deficiencies, and technological challenges. This requires a dynamic and adaptive leadership approach that continuously assesses the unique impacts of virtual settings to ensure effectiveness and team cohesion (Cascio & Shurygailo, 2003). Thus, the role of DLCs is important to ensure the effectiveness of virtual teams (Wang & Wang, 2022). While the broader impact of DL on organizational outcomes—such as employee innovative work behavior, firm innovation performance, and facilitation of digital transformation—is well-documented (AlNuaimi et al., 2022; Benitez et al., 2022; Erhan et al., 2022; Wang et al., 2022; Yao et al., 2024), the specific influence of DLCs on virtual team dynamics remains underexplored. This is particularly critical in addressing challenges such as communication barriers and trust issues that are unique to virtual environments (Cascio, 2000; Horwitz et al., 2006).

The COVID-19 pandemic, coupled with technological advancements, has intensified the use of virtual collaboration tools, especially in creative industries, highlighting the importance of digital communication competencies (Wang & Wang, 2022). Effective digital leaders employ e-communication and e-social skills to mitigate the absence of non-verbal cues in virtual settings, fostering a sense of community and encouraging collaboration (AlAjmi, 2022; Chamakiotis et al., 2021; Efimov et al., 2020). Furthermore, e-trust is essential for establishing reliable and transparent relationships in virtual environments, which enhances team cohesion and morale—both vital for effective collaboration (Pagdanganan, 2022). Regarding e-tech and e-change, DL can enhance digital environments by using the existing technology or changing to the proper one to interact with employees who are recognized for offering beneficial opportunities (Roman et al., 2019). This technology may also pose significant challenges; DL should ensure employees are concerned about it and have the necessary skills. Moreover, an effective DL facilitates the

development of e-team coordination, engagement, and integration, ultimately leading to teams that can self-manage (Soon & Salamzadeh, 2021). Lim (2018) further supports this view by showing that IT-enabled awareness fosters self—directed leadership behaviors in virtual teams through task visibility, presence indicators, and communication disclosure. These behaviors enhance task coordination, interpersonal helping, and team alignment in distributed settings. In line with these findings, digital leadership competencies (e.g., e-communication, e-trust, e-social) serve not only to guide teams but also to create awareness-rich environments that empower individuals to manage their roles proactively and collaboratively. Thus, DLCs can be seen as key enablers of shared leadership and mutual accountability in tech-mediated teams.

Social Exchange Theory (SET) provides a strong theoretical foundation for understanding how digital competencies contribute to virtual team effectiveness. SET is a recursive cycle of giving and receiving that occurs when individuals or groups exchange resources, emotions, knowledge, and efforts (Homans, 1958). Therefore, individuals will proactively engage and sustain exchange relationships with others in anticipation of receiving rewards (Blau, 1964). Digital leaders use technology to communicate with their team to ensure clear communication and build trust through prompt feedback to promote creativity and teamwork, fostering a collaborative and respectful environment that aligns with SET principles. From the perspective of SET, the reciprocal dynamics of these interactions guarantee that leadership behaviors promoting transparent communication, trust, and technology support result in heightened team commitment and performance, hence reinforcing the beneficial influence of digital leadership on virtual teams. Thus, the following hypothesis is proposed:

H1: *Digital leadership competencies will be positively related to virtual team effectiveness.*

The Mediating Role of Knowledge Sharing

Knowledge sharing refers to the dissemination of information, expertise, and ideas pertaining to tasks, as well as the collaboration with others to address issues, develop new ideas, or implement processes (Wang & Noe, 2010). It occurs through various forms of —whether face-to-face or virtual—using digital platforms, documents, and collaborative discussions, enabling employees to access and acquire knowledge efficiently (Fatima & Masood, 2024). It also involves the accessibility, documentation, and organization of relevant information for effective use (Wang et al., 2014). Despite its importance, limited research explores how leadership fosters knowledge sharing in virtual work environments (Fatima & Masood, 2024; Wang & Noe, 2010).

Leadership style is a critical catalyst in the knowledge management process within organizations. Behaviors that promote knowledge sharing help create a sense of inclusion, cohesion, and mutual respect among team members (Kramer, 2006). When leaders encourage these behaviors, employees feel a stronger connection to the organization and their colleagues, motivating them to contribute their knowledge for collective success (Jasimuddin et al., 2006). This is aligned with Social Exchange Theory, which posits that team members are more willing to share knowledge when they believe their contributions will be reciprocated and appreciated (Blau, 1964).

With the increasing prevalence of virtual work, traditional leadership competencies are no longer sufficient. This shift has led to the emergence of DL to sustain knowledge exchange and team engagement across remote settings. According to Roman et al. (2019), DLCs comprise six core competencies: e-communication, e-social, e-change management, e-team, e-tech savvy, and e-trust. Leaders with strong DLCs create a psychologically safe environment that encourages openness and transparency, thereby reducing the risks associated with sharing knowledge (Christensen & Pedersen, 2018; Kankanhalli et al., 2005). These competencies are crucial in virtual contexts where face-to-face interactions are limited. Thus, Leaders skilled in e-communication and e-social competencies effectively bridge communication gaps, ensuring that employees remain connected and engaged in exchanging valuable insights. At the same time, competencies like e-trustworthiness and e-team strengthen trust in leadership, cultivating a collaborative and knowledge-centric organizational culture (Roman et al., 2019). Moreover, by effectively using digital

tools, leaders strengthen their e-tech and e-change management capabilities, enabling seamless knowledge exchange and coordination (Hoch & Dulebohn, 2017).

Knowledge sharing is vital in enhancing the employees' outcomes. It acts as a critical mechanism by promoting better task execution, more effective problem-solving, and improved decision-making through the exchange of ideas and information (Wang & Noe, 2010). In virtual environments, where tasks are often complex and require specialized knowledge, aggregating insights from diverse individuals strengthens individual learning capabilities and boosts overall team performance. This creates a more cohesive, innovative, and productive workplace (Xiao & Jin, 2010). Consequently, the effectiveness of virtual teams is contingent not only on the digital competencies of the leader but also on the extent to which team members engage in knowledge sharing.

Knowledge sharing is crucial in translating digital competencies into virtual team effectiveness (Pangil & Chan, 2014; Christensen & Pedersen, 2018). Leaders foster open communication, encouraging team members to exchange knowledge, enhancing individual and group capabilities (Srivastava et al., 2006). Additionally, digital leaders structure the flow of knowledge through communication technologies, ensuring accessibility regardless of physical location (Nonaka, 1994). By embedding knowledge sharing into the organizational culture, leaders empower teams to innovate, solve problems, and remain effective over time. Thus, knowledge sharing serves as a vital mediator linking DLCs and virtual team effectiveness. Accordingly, we propose the following hypothesis:

H2: *Knowledge sharing mediates the relationship between digital leadership competencies and employee virtual team effectiveness.*

The Mediating Role of Happiness at Work

Happiness at work has lately gained significant attention as a crucial subject within the human resources domain of organizations (Fisher, 2010). Contemporary organizational research underscores the important role of happiness in the workplace in driving positive outcomes (Achor, 2011; Diener & Seligman, 2004; Lyubomirsky et al., 2005). Fisher (2010) defines happiness at work through three dimensions: the nature of the work, the attributes of the job, and the organization overall. Factors such as job inspiration, shared organizational values, interpersonal connections, and leadership significantly affect workplace happiness (Chaiprasit & Santidhiraku, 2011). Effective leadership—characterized by inspiration, awareness, and commitment—can significantly enhance employees' happiness (Chaiprasit & Santidhiraku, 2011). In the context of digital work environments, digital leadership competencies (DLCs) have emerged as crucial elements for fostering a positive atmosphere and maintaining team effectiveness (Joo, 2022; Mo et al., 2024). These competencies provide a sense of security among employees, contributing positively to their emotional well-being and overall happiness (Joo, 2022).

Social Exchange Theory (SET) supports this perspective by proposing that workplace relationships are based on reciprocal exchanges. Employees who perceive emotional support and recognition reciprocate with trust, cooperation, and prosocial behaviors (Organ, 1977). This mutual exchange is particularly critical in virtual settings, where workplace happiness fosters trust, emotional support, and collaborative engagement (Shore et al., 2006).

Leaders who exhibit strong DLCs play a pivotal role in establishing and sustaining virtual teams by selecting effective communication platforms, demonstrating technical expertise, managing digital change, fostering happy work environments, and promoting e-trust (Van Wart et al., 2019). Moreover, DLCs can strengthen e-team competency by encouraging unity and shared objectives to enhance cohesion, which is essential for effective virtual team success. Trust is particularly vital in virtual environments, where physical separation may impede communication and collaboration (Shore et al., 2006). Employees who experience trust and maintain effective communication with their leaders are likelier to report higher levels of happiness and engagement, which significantly affect their happiness (Misra & Srivastava, 2022; Shore et al., 2006)).

E-trust—comprising leadership credibility, professionalism, promotion of work-life balance, diversity, and cooperation—leads to increased individual productivity and happiness (Van Wart et al., 2019).

Furthermore, leadership effectiveness in digital contexts includes readiness for change, monitoring implementation, and technological fluency (Van Wart et al., 2016). Digital leaders can manage e-tech and e-change transitions as technology evolves, enhancing employee satisfaction and well-being (Soon & Salamzadeh, 2021). Equally important are e-social skills, as leaders lacking interpersonal effectiveness in digital spaces may fail to engage their followers, potentially resulting in isolation and disengagement (Roman et al., 2019). Conversely, those with strong e-social skills can foster a sense of belonging, alignment with organizational goals, and overall workplace well-being.

Emotions in the workplace significantly influence organizational outcomes such as job performance, decision-making, problem-solving, citizenship behavior, and leadership (Dewi & Sjabadhymi, 2021). Happiness strengthens workplace connectivity and facilitates coordination and cooperation among team members (Shankar Pawar, 2008), contributing to a unified environment essential for success (Pryce-Jones & Lindsay, 2014).

Based on this theoretical and empirical foundation, workplace happiness serves as a mediating mechanism between DLCs and VTE. DL not only influences team performance but also shapes individual members' experiences amid the challenges of remote collaboration (Mayer et al., 2023). Thus, workplace happiness functions as the emotional and psychological bridge linking DLCs to VTE. It initiates a cycle of reciprocal engagement: when employees feel supported and happy, they are more likely to invest in their work, engage with colleagues, and contribute meaningfully to team dynamic factors critical for effective virtual teamwork (Meng, 2015). This study, therefore, proposes the following hypothesis:

H3: *Happiness at work mediates the relationship between digital leadership competencies and virtual team effectiveness.*

METHODS

Data Collection Procedures and Sample

In this study, we adopted a quantitative approach to investigate how digital leadership competencies impact the effectiveness of virtual teams, with a particular emphasis on the mediating roles of knowledge sharing and happiness at work. Our sample comprised full-time employees from organizations in Saudi Arabia. It is important to clarify that while we recognize remote work as one of the strategies adopted by many organizations during the pandemic, our selection criteria were not based exclusively on the companies' ability to survive because of remote work. Rather, we targeted organizations that demonstrated resilience during the pandemic, focusing on employees who worked in virtual teams.

To identify suitable participants, we used a snowball sampling technique frequently applied in social sciences for reaching specific populations (Atkinson & Flint, 2004). The sample included both public and private sector organizations, selected based on their size and resilience during the pandemic. Specifically, we included two prominent public sector organizations in Saudi Arabia, each employing over 2,000 employees, where many staff worked remotely during the pandemic. We contacted these organizations via publicly available communication channels, including their websites and social media. We requested their assistance in distributing our survey to employees who met the criteria of working in virtual teams. Moreover, to ensure the right respondents worked virtually, the survey introduction explicitly stated that respondents should evaluate their experiences within a virtual/digital work environment.

Our data collection occurred between July and December 2022, when we received 242 responses. Following standard procedures for handling missing data (Newman, 2014), we used listwise deletion, removing cases with incomplete data for any variables critical to the analysis. After cleaning the data, we retained 191 valid responses, which provided sufficient statistical power for our structural model analysis. We used the a priori method outlined by Soper (2021) to ascertain the appropriate sample size for our structural model, which indicated a minimum need of 137 respondents. This computation accounted for a medium effect size of 0.3 (Cohen, 1992), statistical power of 0.80, four latent variables, and 42 observable variables at a 0.05 significance level.

The demographics of our participants presented a near-even gender split, with 54% females (104) and 46% males (87). The age distribution was predominantly within the 30-49 range, the largest segments being 40-49 years (30%) and 30-39 years (28%), while participants aged 60 and above constituted the smallest group at 6%. Educational backgrounds varied, with the majority holding bachelor's (48%) or master's degrees (32%), and a smaller proportion having only high school education (6%). In terms of work experience, a significant portion had over 20 years (33%), followed by those with 1-5 years (20%) and 6-10 years (17%). Importantly, over half of the participants (52%) had 1-5 years of experience in virtual teams, and 37% had less than a year. Regarding their employment sectors, 58.6% worked in the public sector and 41.4% in the private sector. A detailed demographic breakdown and descriptive analysis are in Table 2 of our study.

TABLE 2
SAMPLE CHARACTERISTICS

Demographic Variables	Frequency (N = 191)	Percentage (%)
Gender		
Female	104	54
Male	87	46
Age		
20 to 29	26	14
30 to 39	54	28
40 to 49	58	30
50 to 59	41	22
60 and above	12	6
Education		
High school	12	6
Bachelor's degree	91	48
Master's degree	62	32
Doctorate degree	22	12
Others	4	2
Sector		
Private	79	41
Public	112	59
Work experience		
Less than 1 year	6	3
1 to 5 years	38	20
6 to 10 years	32	17
11 to 15 years	26	13
16 to 20 years	27	14
More than 20 years	62	33
Virtual work experience		
Less than 1 year	70	37
1 to 5 years	100	52
6 to 10 years	10	5
11 to 15 years	1	1
16 to 20 years	8	4
More than 20 years	2	1
Have you ever been a virtual team leader?		
Yes	83	44
No	108	56

Measures

In the current study, we predominantly sourced our survey items from pre-existing validated scales (refer to Appendix A). Unless otherwise indicated, all items were gauged using a five-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). Since the questionnaire was disseminated in Saudi Arabia, the original items were composed in English and translated into Arabic. We employed Brislin's (1980) back-translation technique for the English-Arabic translation process. In order to mitigate any possible biases in interpretation induced by translation challenges, we enlisted the assistance of three experts in the field to translate the English questionnaire into Arabic. This was done since the study primarily concentrated on Saudi employees. Subsequently, a proficient translator who lacked knowledge of the study background and aims rendered the Arabic questionnaire into English.

The 12-item scale created by Roman et al. (2019) measured ***digital leadership competencies***. Participants were asked to indicate how much they agreed or disagreed with a series of statements addressing their opinion on their digital leader competencies. A sample item was "In his/her virtual communication, the leader is clear, well organized, and allows for feedback to avoid errors and untested assumptions. "Team member provided their ratings on ***knowledge sharing*** using Staples and Webster's (2008) four-item scale. One of these items was reverse coded: "My team members keep their best ideas to themselves." A sample item was "My team members share their ideas openly." We adapted Singh and Aggarwal (2018) with a 12-item scale to measure ***happiness at work***. Participants were asked to indicate how much they agreed or disagreed with a series of statements on their happiness at work. An example item is "I enjoy what I am doing at work." Five of these items were reverse coded and distinguished by marking (*). ***Virtual team effectiveness*** was measured using the 8-item scale developed by Pangil and Chan (2014). In the survey instructions provided to respondents, we explicitly emphasized that they should evaluate their team's effectiveness based on experiences within digitally mediated or virtual team interactions. This ensured clear alignment between the measured constructs and the digital focus of our study. We asked the participants to indicate to what extent they agreed or disagreed with a set of statements regarding their virtual team's effectiveness. An example item is "My team is currently meeting its business objectives." All our measures are reflective in nature.

Analytical Tools

This study utilized SmartPLS 4.0 software (Ringle et al., 2015) to analyze the structural relationships within the model (see Figure 1). The use of PLS-SEM was selected due to our data's non-normal distribution, making it a more appropriate choice compared to covariance-based SEM (CB-SEM), as Hair et al. (2017) recommended. To confirm the data's non-normality, we conducted the Kolmogorov-Smirnov and Shapiro-Wilk tests (Sarstedt & Mooi, 2014), both of which yielded significant results ($p < 0.05$). These findings justified the application of PLS-SEM, which is well-suited for non-normally distributed data as it does not rely on the stringent parametric assumptions required by CB-SEM (Vaithilingam et al., 2024).

This report aims to test the relationships between the variables as proposed in the framework (Figure 1) using the structural equation modeling (SEM) method via the Smart-PLS version 4.0. Reflective measurement models, as used in this study, assume that latent variables cause the observed indicators, making standard PLS suitable (Hair et al., 2017). PLS-SEM is particularly advantageous for analyzing correlations within structural relationships in emerging research areas (Henseler, 2018; Latan, 2018) and exploring new phenomena (Richter et al., 2015). It is also recommended for studies with smaller sample sizes due to their greater statistical power compared to CB-SEM, especially for complex models (Hair et al., 2021). This aligns with our study, which uses a sample of 191 responses. PLS-SEM's increasing acceptance among editors, reviewers, and scholars is due to its robustness and versatility (Latan, 2018).

The SEM was conducted using a stages measurement model and a structural model. The measurement model evaluates the model using confirmatory factor analysis (CFA) to achieve the best model fit. The convergent and discriminant validity should be within the thresholds to reach the best model fit. The second stage is testing the Structural model, which tests the relationships between the variables based on the theoretical background and paths/hypotheses. They were presented using the value of β=Coefficient path. T=T-statistic and Square=R^2 (Hair et al., 2021).

In addition to PLS-SEM, we conducted both importance-performance map analysis (IPMA) and necessary condition analysis (NCA). IPMA allows researchers to identify critical areas for improvement by mapping the importance and performance of various constructs, thus providing actionable insights for enhancing outcomes (Hair et al., 2017). This technique is particularly useful in highlighting which variables have high importance but low performance, guiding managerial focus on areas with the most significant impact potential. On the other hand, NCA is a relatively new method in social sciences that helps identify necessary conditions, but not necessarily sufficient, for achieving a particular outcome (Dul, 2016). By integrating NCA with PLS-SEM, we can uncover conditions that must be present for the desired results to occur, thereby offering a deeper understanding of the underlying mechanisms in our study.

RESULTS

Common Method Bias

Following the approach of Matook et al. (2015), our research utilized their method to tackle the issue of Common Method Bias (CMB) to ensure robustness and comparability. We implemented both procedural and statistical remedies to minimize the potential effects of CMB, which can arise from the measurement method rather than the constructs of interest.

We implemented both counterbalancing question order and ensuring respondent anonymity for procedural remedies. We randomized the order of questions to prevent any systematic response bias. Additionally, participants were assured of their anonymity to reduce social desirability bias and encourage honest responses.

We assessed multicollinearity and common method bias (CMB) using the Variance Inflation Factor (VIF), following Hair et al. (2021) and Kock (2015). VIF values above 3.3 may indicate pathological collinearity and CMB (Kock, 2015), and values over 5 suggest broader issues (Hair et al., 2021). All inner model VIFs ranged from 1.363 to 3.3, confirming no multicollinearity or CMB and supporting the model's robustness (Hair et al., 2021; Benitez et al., 2020; Kock, 2015).

To detect Common Method Variance (CMV) issues in PLS-SEM models, we used a marker variable technique suggested by Sarstedt et al. (2022). We incorporated a theoretically unrelated marker variable – participants' attitudes towards the color blue, measured with a 7-item scale developed by Miller and Simmering (2023) – to control its effect. Following Lindell and Whitney (2001), the partial correlation analysis confirmed that the inclusion of this marker variable did not significantly alter the correlations among the constructs of interest.

Finally, a partial correlation analysis was conducted to examine the potential impact of CMV. The results showed that the outer and inner VIF values were <5 and <3.3, respectively, confirming the absence of significant CMB and CMV. Both procedural and statistical remedies affirm the robustness of our findings, providing confidence that CMB and CMV do not significantly impact our model.

Control Variables

In addition to the hypothesized relationship between digital leadership competencies, knowledge sharing, happiness at work, and virtual team effectiveness, we examine the additional effect of using control variables. The conceptual model included the control variables (age, gender, education, sector, and work experience). We first control gender because previous research suggests gender diversity can influence team outcomes (Mohammed & Angell, 2004). Thus, we assume that virtual team effectiveness may vary when the team includes more males or females. Additionally, we used age and work experience as control variables. According to Paul et al. (2016), age and gender positively impact virtual team effectiveness, while work experience has a negative impact. They claim that a virtual team performs better when its members are older, have a higher percentage of women, and have less work experience. Moreover, we assumed that virtual team effectiveness may differ when applied in the public or private sector. On that basis, we used these control variables in our hypothesis testing. Specifically, we controlled for overall working experience with six response options (1= less than 1 year; 2= 1 to 5 years; 3= 6 to 10 years; 4= 11 to 15 years; 5= 16 to 20 years; 6= More than 20 years). Gender was dummy coded, with females coded

zero and males coded 1. Age was controlled with five response options (1= 20 to 29 years old; 2= 30 to 39 years old; 3= 40 to 49 years old; 4= 50 to 59 years old; 5= 60 years and above). Moreover, the firm sector was coded as a dummy variable (1 = Private, 0 = Public).

Measurement Model

The measurement model was estimated and drawn on the recommendations found by Hair et al. (2021). The threshold values applied during the evaluation of the measurement model are as follows:

Reliability

The measurement model meets all required statistical standards. As shown in Table 3, most items have factor loadings (FL) above the recommended threshold of 0.708, indicating strong item reliability (Hair et al., 2017; Latan, 2018). A few items, however, had loadings between 0.50 and 0.60. Following established guidelines (Hair et al., 2017; Chin, 1998), we retained these items (DLC9, DLC15, HAW12, VTE9) because they capture critical conceptual aspects of the constructs. Excluding them would undermine the constructs' theoretical coherence and conceptual completeness, justifying their inclusion despite the lower loadings.

Moreover, according to Hair et al. (2017), items with loadings below 0.50 should generally be considered for removal, as such loadings suggest weak indicator reliability. In line with this recommendation, we deleted items with loadings below this threshold, such as HAW 10 & 11, VTE 6 & 8, and DLC 2, 3, 4, 7, 13, and 18, to ensure the robustness of the measurement model. Each factor loading was further evaluated for statistical significance by examining the t-statistics. Items were retained if they met the significance threshold of a t-statistic ≥ 1.96 at a 5% significance level using a two-tailed test (Roldán & Sánchez-Franco, 2012), confirming that the retained items contributed significantly to the constructs.

Moreover, the internal consistency and reliability of the constructs were rigorously assessed. The Cronbach's alpha (CA), Dijkstra-Henseler's rho (ρA), and composite reliability (CR) for all variables exceeded the recommended threshold of 0.70, with most values above 0.80, which further indicates strong internal consistency and reliability of the constructs (Hair et al., 2017). These results demonstrate that the measurement model was reliable and met the necessary criteria for construct validity.

TABLE 3
MEASUREMENT MODEL RESULTS

Constructs	Items	FL	VIF	CA	Rho_a	CR	AVE
Digital leadership competencies (DLC)	DLC1	0.696	1.933	0.918	0.926	0.93	0.531
	DLC5	0.656	1.808				
	DLC6	0.773	2.409				
	DLC8	0.803	3.055				
	DLC9	0.589	1.704				
	DLC10	0.828	3.463				
	DLC11	0.826	3.593				
	DLC12	0.798	3.351				
	DLC14	0.707	1.878				
	DLC15	0.530	1.655				
	DLC16	0.679	2.442				
	DLC17	0.791	2.859				

Happiness at work (HAW)	HAW1	0.596	1.69	0.87	0.883	0.896	0.468
	HAW2	0.630	1.722				
	HAW3	0.768	2.141				
	HAW4	0.749	1.967				
	HAW5	0.771	2.68				
	HAW6	0.548	1.637				
	HAW7	0.660	1.795				
	HAW8	0.758	3.346				
	HAW9	0.771	3.34				
	HAW12	0.524	1.457				
Knowledge sharing (KSH)	KSH1	0.857	2.233	0.877	0.887	0.916	0.732
	KSH2	0.898	2.814				
	KSH3	0.873	2.432				
	KSH4	0.789	1.881				
Virtual team effectiveness (VTE)	VTE1	0.811	2.228	0.884	0.895	0.913	0.641
	VTE2	0.836	2.565				
	VTE3	0.824	2.252				
	VTE4	0.849	2.707				
	VTE5	0.856	2.517				
	VTE7	0.596	1.363				

Note: FL = Factor loadings; VIF = Variance Inflation Factor; CA = Cronbach's Alpha; CR = Composite reliability; *Rho_a* = Dijstra-Henseler's rho; CR = Campsite reliability; AVE = Average variance extracted. DLC = digital leadership competencies, HAW= Happiness at work, KSH= Knowledge sharing, VTE= Virtual team effectiveness

Validity

To evaluate the measurement model, we assessed convergent and discriminant validity. Convergent validity was examined through Average Variance Extracted (AVE) values. As shown in Table 3, all AVE values exceeded the 0.50 threshold, indicating that at least 50% of the indicators' variance was explained by their respective constructs (Hair et al., 2021), except Happiness at Work, which fell slightly below this cutoff. Despite the marginally low AVE for Happiness at Work, we retained the construct due to its robust composite reliability (CR > 0.70), aligning with methodological guidance from Hair et al. (2011) and supported by recent empirical evidence from Cram et al. (2022). These sources confirm that constructs with high composite reliability and clear theoretical importance remain valid even when AVE is slightly below 0.50.

Discriminant validity can be determined by examining several analyses, such as the Fornell-Larcker criterion, which suggests that the square root of AVE is greater than the correlation among latent variables (Hair et al., 2021), and the heterotrait-monotrait (HTMT) ratio of correlations approach, which suggests that HTMT index should be less than HTMT 0.85 or HTMT 0.90 (Henseler et al., 2015).

In PLS-SEM, discriminant validity is assessed by assessing the heterotrait–monotrait ratio (HTMT), as seen in Table 4; all values were less than 0.8 (Hair et al., 2021; Henseler et al., 2015). Franke and Sarstedt (2019) stated that the HTMT ratio of correlations is considered a more accurate estimator of deattenuated (i.e., completely reliable) correlations between variables than other methods. In addition, each construct was examined using the Fornell–Larcker criteria. In addition, the findings demonstrated that the square root of the AVE scores surpassed the correlation coefficients among the variables (Fornell & Larcker, 1981), indicating that essential discriminant validity had been attained (Endara et al., 2019).

We also estimated three discrepancies between the empirical correlation matrix and the model-implied correlation matrix of the estimated model: SRMR, d_{ULS}, and d_G (Benitez et al., 2020). In evaluating the structural equation model, we focused on the goodness of fit indices, particularly the Standardized Root

Mean Square Residual (SRMR). SRMR is a critical measure in SEM, assessing the average discrepancy between the observed correlations and the model's predicted correlations. Our model exhibited an SRMR value of 0.08, as highlighted by Hair et al. (2019), which is within the acceptable range. This indicates a good fit, suggesting minimal disagreement between the implied and observed models. Such a result underscores the adequacy of our model in representing the underlying data.

In our analysis, the discrepancy measures d_ULS and d_G exceeded their respective reference distributions' 95% and 99% quantiles (HI95 & HI99). This result suggests that these two indices do not support the model fit as strongly as the Standardized Root Mean Square Residual (SRMR). Specifically, when d_ULS and d_G values surpass these quantiles, it indicates that the model may not fully capture the complexity or variability within the dataset. This could imply that the model might be oversimplified or insufficiently nuanced to represent the richness of the data (Henseler et al., 2015; Benitez et al., 2020).

However, despite the elevated values of d_ULS and d_G, the SRMR remains below the threshold for acceptable model fit. SRMR is widely recognized as a reliable and robust indicator of model fit in structural equation modeling, especially in cases where other indices like d_ULS and d_G suggest a weaker fit (Hu & Bentler, 1999; Hair et al., 2019). Recent research also suggests that, under certain conditions, discrepancy measures such as d_ULS and d_G may be less critical, as SRMR often provides a more reliable indication of overall model adequacy (Benitez et al., 2020).

Therefore, although the d_ULS and d_G indices indicate that the model may not fully account for all the complexities of the data, the SRMR suggests that the model fits the data adequately. This is further supported by the fact that SRMR is considered sufficient to confirm model fit in many structural equation modeling applications (Henseler et al., 2016).

Correlation Analysis

In Table 4, the correlation analysis between the study variables shows that digital leadership competencies were positively correlated with happiness at work, knowledge sharing, and virtual team effectiveness ($r = 0.619$, $p < 0.01$; $r = 0.554$, $p < 0.01$; $r = 0.621$, $p < 0.01$, respectively); furthermore, virtual team effectiveness was positively correlated with happiness at work and knowledge sharing ($r = 0.605$, $p < 0.01$; $r = 0.707$, $p < 0.01$, respectively), providing initial support for the hypotheses. Moreover, in the present study, the statistical significance of the correlations among all the constructs of interest persisted, as anticipated, even after controlling for the impact of the marker variable (refer to Table 4). This suggests that the potential influence of CMB on the results was not significant.

TABLE 4
DISCRIMINANT VALIDITY RESULTS FROM FORNELL-LARCKER, HTMT, AND CORRELATIONS

Variables	**DLC**	**HAW**	**KSH**	**VTE**
DLC	**0.729**	0.699[h]	0.618 [h]	0.723 [h]
HAW	0.643	**0.684**	0.442 [h]	0.722 [h]
KSH	0.568	0.401	**0.855**	0.788 [h]
VTE	0.676	0.648	0.695	**0.800**
DLC	-	0.611[**b]	0.549[**b]	0.617[**b]
HAW	0.619[**c]	-	0.375[**b]	0.600[**b]
KSH	0.554[**c]	0.383[**c]	-	0.704[**b]
VTE	0.621[**c]	0.605[**c]	0.707[**c]	-
Mean	4.046	3.791	4.238	4.213
Standard Deviation	0.711	0.828	0.775	0.947

Note: N= 191, *|t|≥ 1.65 at p 0.05 level; **|t|≥ 2.33 at p 0.01 level; ***|t|≥ 3.09 at p 0.001 level. DLC = digital leadership competencies, HAW= Happiness at work, KSH= Knowledge sharing, VTE= Virtual team effectiveness;

h= The values of the heterotrait–monotrait ratio (HTMT). c = correlations; b = Correlations controlled by the Marker Variable (attitude toward blue color).

Structural Model

The structural model was estimated following guidelines from Hair et al. (2021). Multicollinearity among independent variables was assessed using the variance inflation factor (VIF), as detailed in the common method variance section. With VIF values ranging from 1.363 to 3.593—well below the threshold of 5 (Hair et al., 2021; Benitez et al., 2020) and meeting Kock's (2015) criterion of 3.3 for the absence of common method bias—the model demonstrates no problematic multicollinearity, supporting the reliability of the structural analysis.

In addition, the coefficient of determination, R^2, determines the model's accuracy. The R^2 values of ≥ 0.25, ≥ 0.50, and ≥ 0.75 are regarded as weak, moderate, and substantial, respectively (Hair et al., 2021). The R^2 coefficient for happiness at work was 0.418, knowledge sharing was 0.339, and virtual team effectiveness was 0.667, which indicates that the R^2 for all variables was considerably moderate (Hair et al., 2021). Furthermore, the predictive sample reuse method (Q^2) may be utilized as a predictive relevance criterion (Chin et al., 2008). Q^2 indicates the extent to which acquired data may be empirically reconstructed using the model and PLS parameters based on the blindfolding procedure. If $Q^2 > 0$, the model's predictive validity is established (Fornell & Cha, 1993; Hair et al., 2021). In this research, Q^2 values of 0.411, 0.307, and 0.451 for happiness at work, knowledge sharing, and virtual team effectiveness, respectively, indicate that all variables had adequate predictive significance.

Hypotheses Testing

SmartPLS 4.0 was used to test the hypotheses. A 10000-iteration bootstrapping approach was employed to determine the statistical significance of the weights of the sub-constructs and path coefficients (Hair et al., 2021). Table 5 and Figure 2 results demonstrate the hypotheses testing when applying the control variables.

As predicted by H1, the effect of DLCs was positive and significant on VTE (β = 0.172, t = 2.071, $p < 0.05$, $f^2 = 0.093$), which supported H1. Moreover, the path coefficient for DLCs was positive and significant on KSH (β = 0.656, t = 7.965, $p < 0.00$, $f^2 = 0.513$), as well as KSH affect VTE relationship positively and significantly (β = 0.456, $t = 4.846$, $p < 0.00$, $f^2 = 0.491$). Also, the indirect effect of DLCs on VTE through KSH (β=0.253, t =4.283, $p < 0.00$), which supported H2. Therefore, KSH partially mediates the relationship between DLCs and VTE. Furthermore, the path coefficients for DLCs were positive and significant on HAW (β = 0.705, $t = 10.315$, $p < 0.001$, $f^2 = 0.718$), and there is a positive effect of HAW on VTE (β=0.325, t =6.454, $p < 0.001$, $f^2 = 0.251$). Also, the indirect effect of DLCs on VTE through HAW (β=0.217, t =5.004, $p < 0.00$). Thus, these findings supported H3 and showed that HAW partially mediates the relationship of DLC-VTE.

Using the effect size (f^2) helps evaluate the variation explained for each predictor in the structural model. The analysis of effect size (f^2) shows how much a predictor (independent) construct affects a dependent construct (Hair et al., 2021). The effect size (f^2) values of all variables are >0.5, which denotes large effect sizes (Chin, 1998). In addition, Table 5 presents the results of the structural model with control variables, demonstrating that none of the control variables (age, gender, education, and work experience) had a significant effect ($p > 0.05$) on virtual team effectiveness. This finding is consistent with previous studies (Lee & Tang, 2018), indicating that the control variables did not compromise the robustness of the structural relationships. However, the sector significantly positively affected virtual team effectiveness (β = 0.127, $t = 1.962$, $p < 0.05$). The results indicate that the private sector exhibits higher virtual team effectiveness than the public sector, as evidenced by the p-value and positive path coefficient. Additionally, the sector shows a significant negative effect on knowledge sharing (β = -0.227, $t = 2.281$, $p < 0.05$), indicating that the private sector generally exhibits lower levels of knowledge sharing than the public sector. Furthermore, education significantly negatively affects happiness at work (β = -0.120, $t = 2.444$, $p < 0.05$).

FIGURE 2
STRUCTURAL MODEL RESULTS

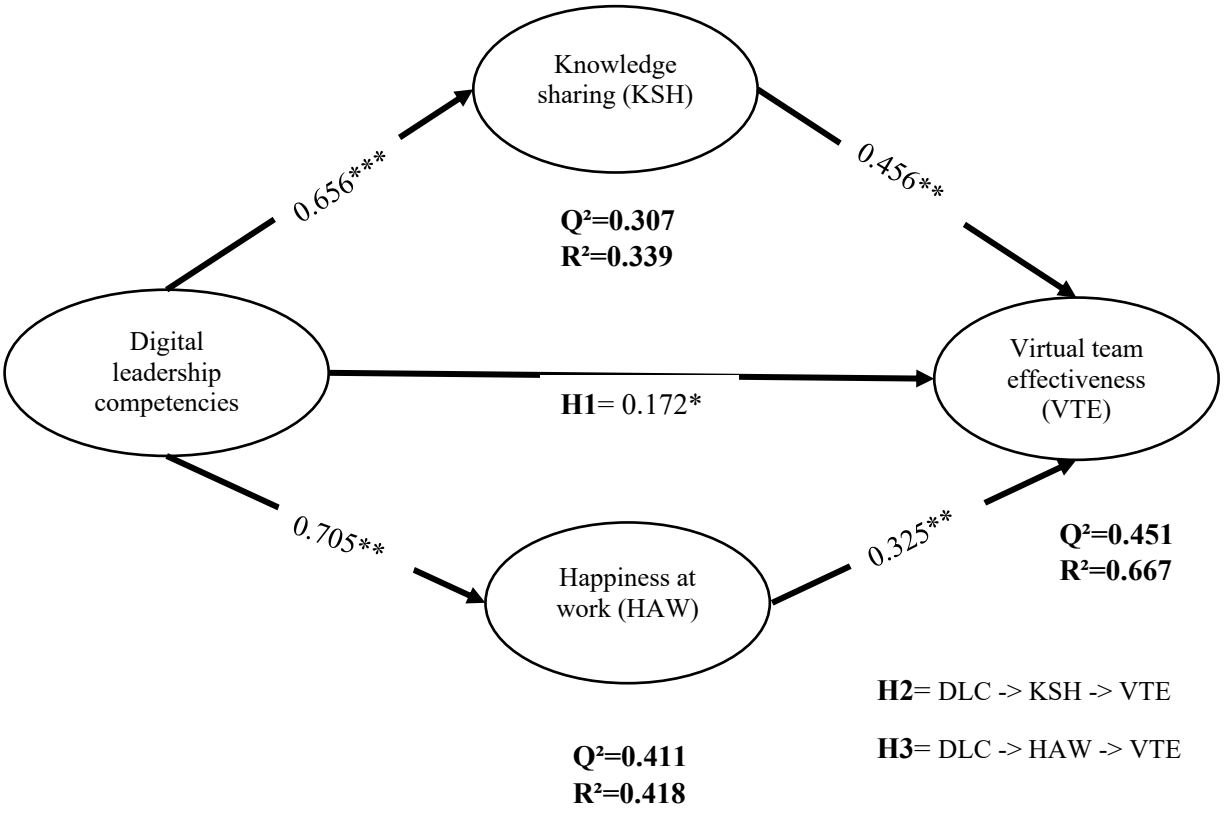


TABLE 5
STRUCTURAL MODEL RESULTS

Variables	Knowledge sharing Q^2 = 0.307 R^2 = 0.339				Happiness at work Q^2 = 0.411 R^2 = 0.418				Virtual team effectiveness Q^2 = 0.451 R^2 = 0.667			
	Path coefficients	95% Bca confidence interval	T statistics	Effect size (f^2)	Path coefficients	95% Bca confidence interval	T statistics	Effect size (f^2)	Path coefficients	95% Bca confidence interval	T statistics	Effect size (f^2)
Control variables												
Age	-0.017	(-0.001, 0.119)	0.235		0.095	(0.00, 0.219)	1.645		-0.067	(0.003, 0.033)	1.299	
EDU	0.104	(-0.004, 0.21)	1.937		-0.120*	(-0.001, -0.022)	2.444		0.019	(-0.002, 0.094)	0.519	
GEN	-0.028	(0.002, 0.197)	0.257		0.019	(0.00, 0.215)	0.191		0.079	(-0.006, 0.222)	1.123	
Wexp	-0.003	(0.001, 0.087)	0.062		-0.022	(0.000, 0.068)	0.450		0.019	(0.001, 0.090)	0.518	
SEC	-0.227*	(0.006,-0.044)	2.281		-0.168	(-0.001, 0.068)	1.454		0.127*	(-0.001, 0.252)	1.962	
Direct effect												
DLC	0.656***	(-0.002, 0.813)	7.965	0.513	0.705***	(-0.003, 0.828)	10.315	0.718	0.172*	(0.001, 0.329)	2.071	0.093
HAW									0.325***	(-0.00, 0.430)	6.454	0.251
KSH									0.456***	(-0.011, 0.623)	4.846	0.491

Direct effect without control variables												
DLC	0.575***	(0.006, 0.688)	7.921	0.494	0.65***	(0.002, 0.723)	12.560	0.737	0.213**	(0.007, 0.35)	2.380	0.062
HAW									0.333***	(0.003, 0.41)	5.478	0.191
KSH									0.440***	(-0.011, 0.621)	4.057	0.387

Specific indirect effect

Variables	**Path coefficients**	**95% Bca confidence interval**	**Standard deviation (STDEV)**	**T statistics**
DLC -> HAW -> VTE	0.217***	(0.005,0.305)	0.043	5.004
DLC -> KSH -> VTE	0.253***	(-0.007,0.376)	0.06	4.283

Note: *$|t|\geq 1.65$ at p 0.05 level; **$|t|\geq 2.33$ at p 0.01 level; ***$|t|\geq 3.09$ at p 0.001 level; BCa = Bias-corrected and accelerated. R^2 = Determination coefficients; Q^2 = Predictive relevance of endogenous; DLC = digital leadership competencies, HAW= Happiness at work, KSH= Knowledge sharing, VTE= Virtual team effectiveness; Age: age; EDU: education; GEN: gender; Wexp: work experience; SEC: sect

Importance Performance Map Analysis

The PLS-SEM analytical tool, Importance-Performance Map Analysis (IPMA), disseminates conventional path coefficient values more practically (Ringle & Sarstedt, 2016). Specifically, IPMA offers a technique that evaluates an item's performance and importance. The purpose is to determine the overall impact of the antecedent construct's significance in predicting a particular target (outcome) construct (Hair et al., 2018).

The overall effects indicate the significance of the preceding constructs— digital leadership Competencies (DLCs), Knowledge Sharing (KSH), and Happiness at Work (HAW)—in influencing the target construct, Virtual Team Effectiveness (VTE), while their performance is indicated by the average value of their scores (0-100) (Höck et al., 2010). From Table 6, DLCs' performance score is 76.7, HAW 71, and KSH 80.87, indicating that all constructs show relatively high performance.

Next, assessing the significance of each antecedent construct concerning its overall impact on the target construct is essential. The total impact of a connection between two constructs is the combined result of both the direct and indirect effects in the structural model.

The overall impact of DLCs demonstrates its significance in forecasting the target variable, VTE. According to IPMA, if the performance of an antecedent (e.g., DLCs) rises by one unit, the performance of the outcome (VTE) will increase by the same amount as the antecedent's unstandardized total effect (Hair et al., 2016). Thus, DLCs have the highest importance score of 0.676, followed by KSH with 0.442, and HAW with the lowest impact, scoring 0.337.

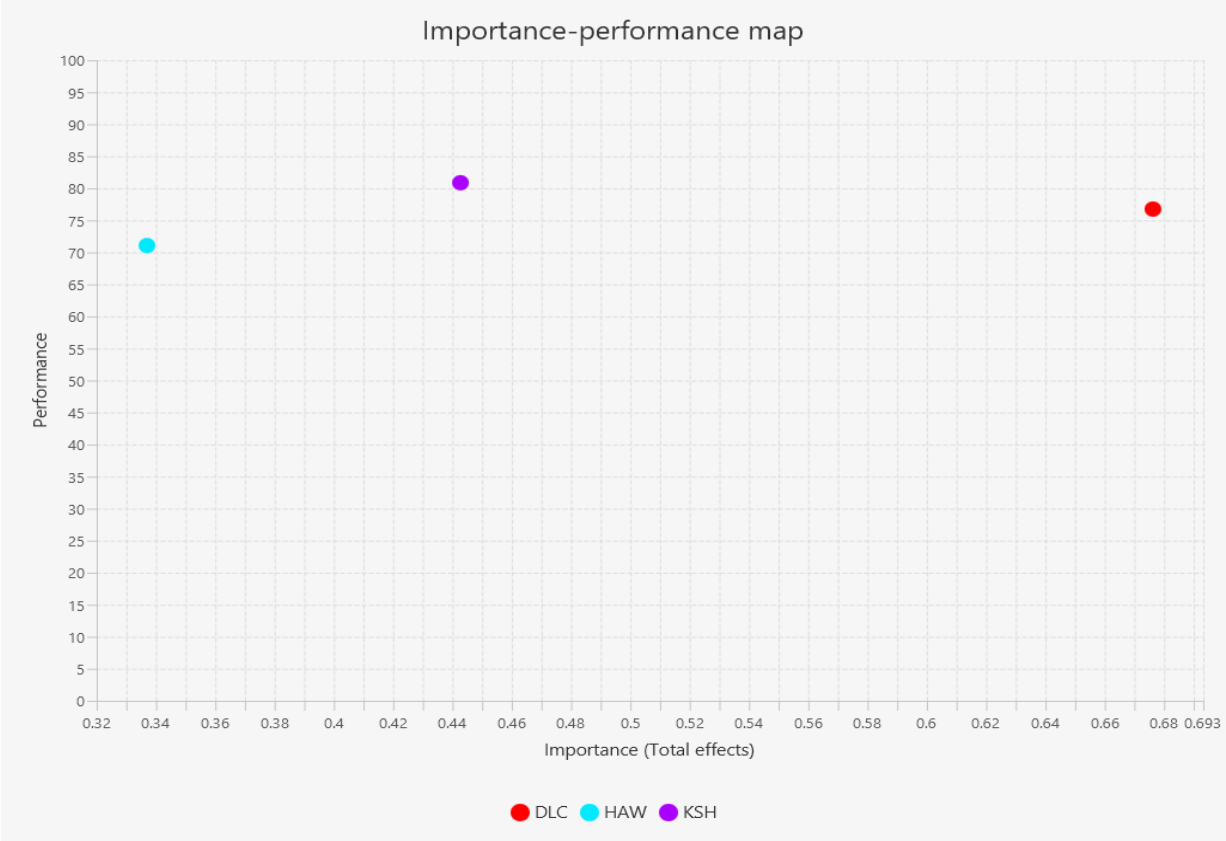
The constructs DLCs, KSH, and HAW, are crucial and performing well, ensuring the effectiveness of virtual teams. The maximum significance score for DLCs is 0.676, indicating that a one-unit increase in DLCs' performance would result in a 0.676 improvement in the total VTE (see Figure 3).

TABLE 6
IMPORTANCE-PERFORMANCE MAP ANALYSIS

Construct	Performance	Importance
DLC	76.765	0.676
HAW	71.071	0.337
KSH	80.875	0.442

Note: DLC: digital leadership competencies; HAW: happiness at work; KSH: knowledge sharing; VTE: virtual team effectiveness.

FIGURE 3
SCATTER PLOTS OF IPMA



Necessary Condition Analysis

This study utilized Necessary Condition Analysis (NCA) alongside Partial Least Squares Structural Equation Modeling (PLS-SEM) to explore the relationships among digital leadership Competencies (DLCs), Happiness at Work (HAW), Knowledge Sharing (KSH), and Virtual Team Effectiveness (VTE). NCA, introduced by Dul (2016), is an innovative methodology and data analysis tool that identifies essential conditions within datasets (Dul, 2016). Unlike traditional methods that examine average relationships between dependent and independent variables, NCA focuses on pinpointing areas in scatter plots where the presence of a necessary condition is evident (Richter et al., 2022). This research sought to ascertain whether DLCs, KSH, and HAW are necessary conditions for achieving VTE. Figures 4-6 present the scatter plots for each pertinent relationship, while Table 7 illustrates the effect sizes.

The NCA results, detailed in Table 7, indicate that DLCs, KSH, and HAW are critical for VTE, demonstrating both practical significance ($d \geq 0.1$) and statistical significance ($p < 0.05$). The analysis using Ceiling Envelopment-Free Disposal Hull (CR-FDH) in Table 7 showed an accuracy level exceeding the 95% standard (Richter et al., 2023).

Bottleneck tables provide a thorough assessment of the necessary conditions. To achieve a 90% level of VTE, the following thresholds must be met: DLCs at least 16.23%, KSH at least 14.66%, and HAW at least 9.948%. The minimum required levels for a maximum VTE score of 100% are DLCs at 16.23%, KSH at 19.372%, and HAW at 17.801%. If the DLCs fall below the 16.23% threshold, attaining a high level of VTE is unattainable.

TABLE 7
BOTTLENECK TABLE AND NCA EFFECT SIZES

Bottleneck CPB	VTE	DLC	HAW	KSH
0.00%	-4.389	0.524	NN	NN
10.00%	-3.85	0.524	NN	1.047
20.00%	-3.312	1.047	NN	1.047
30.00%	-2.774	1.047	NN	1.047
40.00%	-2.235	2.618	NN	1.571
50.00%	-1.697	3.141	NN	1.571
60.00%	-1.159	4.712	NN	2.094
70.00%	-0.621	4.712	NN	2.094
80.00%	-0.082	8.377	NN	5.236
90.00%	0.456	16.23	9.948	14.66
100.00%	0.994	16.23	17.801	19.372
NCA effect sizes (Accuracy and fit are 100%)				
Construct	**CPB CE-FDH**	**Accuracy**		
DLC	0.229***	100%		
HAW	0.076***	100%		
KSH	0.320***	100%		

Note: NCA: Necessary condition analysis; DLC: digital leadership; HAW: happiness at work; KSH: knowledge sharing; VTE: virtual team effectiveness; NN: not necessary

FIGURE 4
NCA CHART-DLC

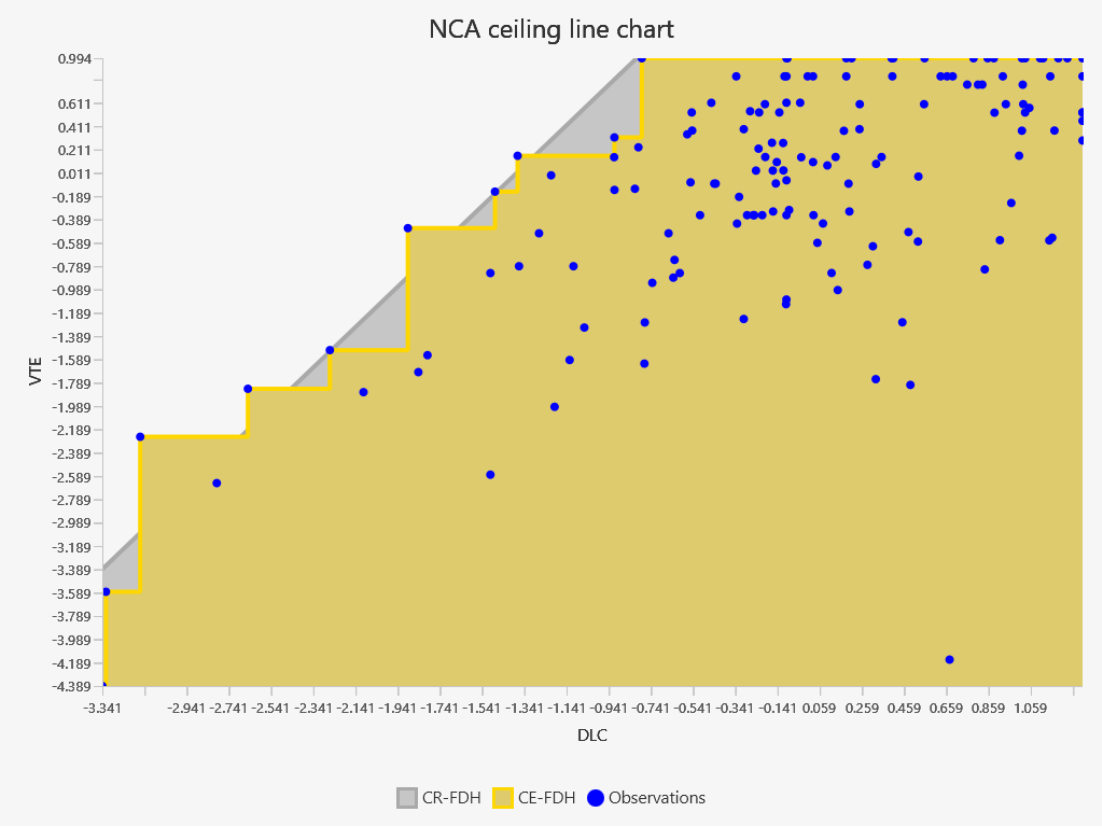


FIGURE 5
NCA CHART-HAW

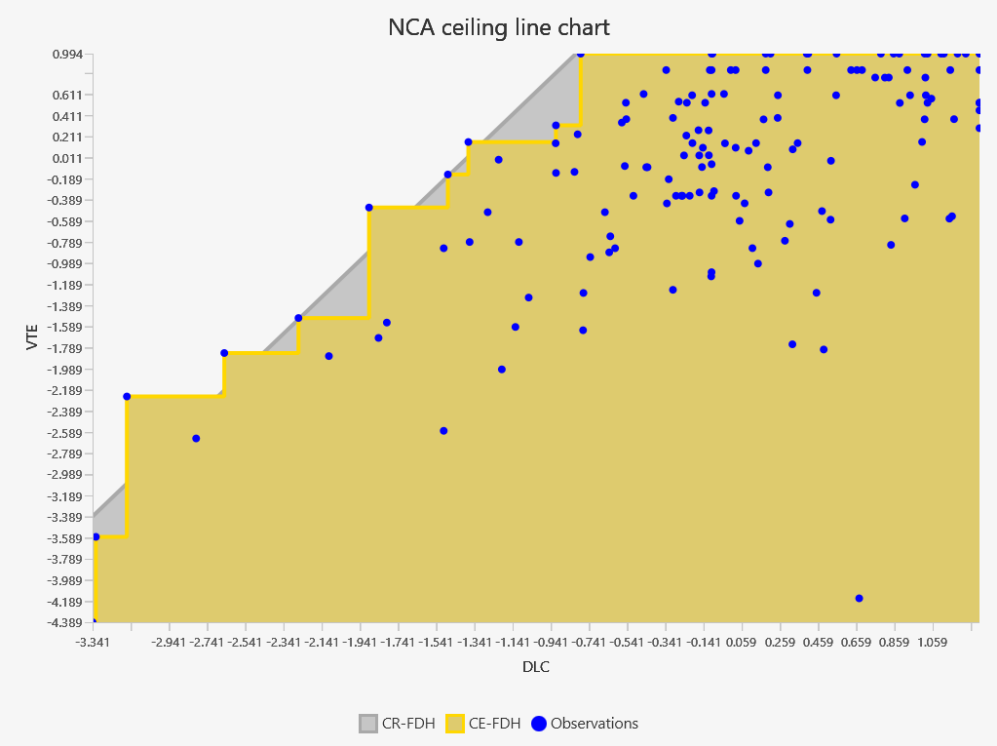
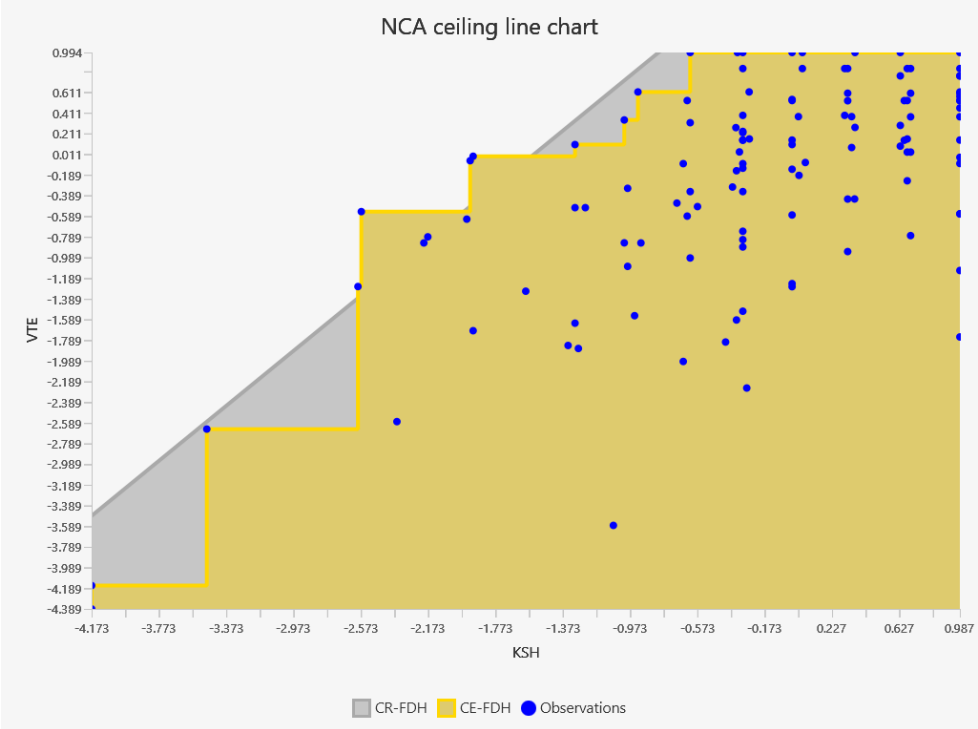


FIGURE 6
NCA CHART- KSH



DISCUSSION

This study investigated how digital leadership competencies (DLCs) affect virtual team effectiveness (VTE), with a particular focus on the mediating roles of knowledge sharing (KSH) and happiness at work (HAW). The findings reveal that DLCs significantly enhance VTE both directly and indirectly through these two mechanisms, offering novel insights into leadership effectiveness within digitalized work environments. These results contribute to both theoretical and practical understanding by advancing the discourse on digital leadership and its role in contemporary organizational settings.

Previous research has emphasized the influence of leadership styles on virtual team dynamics and effectiveness (Hambley et al., 2007; Kahai & Avolio, 2006; Lu et al., 2014; Roman et al., 2019). Our findings extend this body of work by demonstrating that leadership characteristics—particularly digital leadership competencies— play a crucial role in achieving VTE. These competencies include technical expertise, effective communication, trust-building, and the ability to manage social dynamics, all of which are essential for fostering a high-performing virtual team environment. These competencies include technical expertise, effective communication, trust-building, and the ability to manage social dynamics, all of which are essential for fostering a high-performing virtual team environment. While previous studies have explored different leadership styles in enhancing HAW (Salas-Vallina et al., 2020; Salas-Vallina & Alegre, 2018; Semedo et al., 2019), limited research has specifically linked DLCs to HAW. Our findings address this gap by confirming that DLCs positively influence HAW. Leaders equipped with a wide range of digital competencies can enhance employees' sense of security and emotional well-being by fostering a supportive and engaging digital work environment (Joo, 2022). Thus, DLCs meet employees' psychological and emotional needs, thereby increasing their happiness at work.

Although previous studies have demonstrated that workplace happiness contributes to proactive behaviors and positive outcomes (Achor, 2012; Liu et al., 2020; Marinho et al., 2021; Salas-Vallina & Alegre, 2021), its mediating role in the DLCs-VTE relationship remains unexplored. Our findings demonstrate that HAW functions as a psychological catalyst, motivating employees to engage more positively with their virtual teams, ultimately enhancing team effectiveness and overall organizational performance. Furthermore, while previous research only focuses on one of the competencies of the DL to enhance KSH (Pangil & Chan, 2014; Christensen & Pedersen, 2018), our study demonstrates that the broader set of DLCs is essential for fostering KSH, particularly in virtual work contexts. Knowledge sharing serves as a critical mechanism for intellectual exchange, where leadership support increases employees' willingness to share expertise and insights (Wang & Noe, 2010). By cultivating a knowledge-sharing culture through strong digital leadership, organizations can align employees' contributions with strategic goals and enhance collective success (Lee et al., 2013).

By integrating both mediators—knowledge sharing and happiness at work— into a unified framework, this study shifts the focus from direct leadership effects to a more complex, mediated model. Specifically, we show that effective digital leaders facilitate knowledge-sharing behaviors and elevate workplace happiness, thereby fostering an optimal virtual team environment. These findings underscore the necessity of multi-dimensional leadership competencies, including social, communicative, and technical skills, for achieving high team performance in digitalized work contexts.

Our PLS-SEM findings complemented by IPMA and NCA analyses, further highlighting the critical roles of DLCs, KSH, and HAW in enhancing VTE. Our findings highlight that DLCs emerged as the most influential predictor of VTE, reinforcing the important role of strong DL in remote work settings. KSH and HAW also emerged as essential factors, indicating that knowledge sharing and employee well-being are crucial for maximizing team effectiveness. Moreover, the NCA findings revealed that achieving high levels of VTE requires meeting minimum thresholds of DLCs, KSH, and HAW, indicating that these factors are not just facilitators but essential conditions for virtual team success.

Theoretical Implications

This study contributes significantly to theory by expanding and refining the conceptual understanding of digital leadership competencies (DLCs) within virtual team contexts. Traditional leadership theories

often assume a physical or co-located presence, overlooking the unique challenges digitally mediated interactions pose. Our findings explicitly challenge these traditional assumptions by demonstrating that specific DLCs—particularly digital communication, social engagement, trust-building, technological adaptability, and change management—are essential drivers of virtual team effectiveness (VTE).

A primary theoretical advancement of our research lies in re-conceptualizing the influence of DLCs through direct effects and indirect effects through two critical mediators—knowledge sharing (KSH) and happiness at work (HAW). This dual-mediation model provides novel insights into how digital leaders foster environments conducive to intellectual exchanges and psychological well-being. Specifically, DLCs facilitate KSH by overcoming inherent virtual collaboration challenges, such as geographical dispersion, limited interpersonal cues, and difficulties maintaining continuous engagement. This creates a collaborative environment that enhances trust, social cohesion, technical competency, and collective problem-solving capabilities.

Similarly, our study highlights the mediating role of happiness at work, positioning DLCs as vital organizational resources that mitigate the psychological strain employees experience during digital transitions. Competencies such as e-communication and e-social skills enable digital leaders to convey empathy and maintain meaningful interpersonal interactions, significantly contributing to employees' emotional and psychological well-being in virtual settings. By identifying HAW as a crucial psychological mediator, our research emphasizes its role as an essential driver of sustained virtual team performance, encouraging future leadership frameworks to integrate emotional and cognitive dimensions holistically rather than separately.

Further extending these theoretical insights, this research explicitly applies Social Exchange Theory (SET) to digitally mediated environments—an area insufficiently explored in prior literature. Although SET traditionally emphasizes interpersonal reciprocity, trust, and exchanges occurring primarily in co-located contexts (Blau, 1964; Cropanzano & Mitchell, 2005), our findings offer a nuanced perspective by demonstrating how DLCs effectively substitute traditional face-to-face interactions. By enabling high-quality knowledge exchanges, emotional support, and trust despite physical separation, DLCs expand SET's foundational assumptions about social exchange, which traditionally rely on proximity and direct interpersonal interactions. Thus, our study explicitly argues that digitally mediated interactions should be integrated into SET as legitimate and critical contexts for social exchanges. This perspective significantly broadens SET's explanatory power in contemporary, technology-driven work environments.

In line with recent scholarship, our findings underscore SET's adaptability to technology-mediated environments, illustrating how DLCs enable trust- and reciprocity-based exchanges through virtual tools, team alignment technologies, and digitally mediated social cues (e.g., Van Wart et al., 2019; Chen et al., 2018). By doing so, this research explicitly highlights the relevance of SET in contemporary leadership studies, advocating for theoretical developments that systematically consider digital competencies as facilitators of social exchanges in increasingly virtualized work environments.

Finally, this study advocates shifting leadership research from a purely behavioral focus toward integrated models that recognize intellectual, emotional, and technological pathways in virtual team dynamics. It explicitly calls for future theoretical exploration into hybrid work models, technological mediation of social exchanges, and the new competencies required of digital leaders. By providing a detailed understanding of interactions among leadership competencies, social exchanges, and virtual team effectiveness, this research lays a robust foundation for future studies in digital leadership and virtual collaboration.

Managerial/Practical Implications

This study offers practical implications that managers can directly implement to enhance virtual team effectiveness (VTE) through digital leadership competencies (DLCs), knowledge sharing (KSH), and happiness at work (HAW).

First, managers should strategically invest in comprehensive digital leadership development programs specifically targeting the competencies identified as critical in our findings, including digital communication, social intelligence, trust-building, technological proficiency, change management, and

effective virtual team coordination. These competencies are essential—not merely beneficial—in navigating the unique complexities of virtual collaboration. Organizations could implement structured executive training programs, digital leadership boot camps, and personalized cross-functional mentorship initiatives explicitly tailored to reinforce these competencies continuously. Embedding such digital leadership development initiatives into organizational human resource strategies will ensure sustained leadership growth and adaptability.

Second, our empirical results highlight knowledge sharing as a pivotal mediator between DLCs and VTE. Managers should, therefore, prioritize cultivating psychologically safe and trust-driven organizational cultures explicitly designed to facilitate seamless intellectual exchanges among employees. This can involve creating structured digital knowledge-sharing platforms, such as collaborative project management tools, virtual innovation hubs, or internal knowledge bases, enabling employees to exchange expertise efficiently and effectively. Additionally, integrating peer-learning initiatives and gamified learning experiences can stimulate active participation. To reinforce these behaviors further, organizations should explicitly recognize and reward proactive knowledge sharing through performance-based recognition programs, project-based incentives, and digital collaboration awards.

Third, considering our findings that happiness at work significantly mediates the relationship between digital leadership and team effectiveness, managers must explicitly prioritize employee well-being in virtual environments. Organizations can implement advanced, data-driven employee-experience monitoring systems capable of assessing and responding proactively to real-time employee sentiments. Initiatives such as virtual wellness programs, digital counseling services, and virtual team-building activities can be explicitly tailored to support remote workers' emotional and psychological needs. Moreover, providing leaders with personalized development plans focusing explicitly on emotional intelligence, digital empathy, and interpersonal sensitivity will help maintain healthy leader-team relationships, thereby fostering a cohesive, motivated, and psychologically supported workforce.

Finally, organizations should foster a holistic culture emphasizing digital competence, continuous learning, and collaborative excellence explicitly aligned with virtual team dynamics. By adopting an integrated approach that simultaneously strengthens digital leadership capabilities, enhances knowledge-sharing practices, and actively supports employee happiness, organizations will achieve superior virtual team performance and ensure sustained employee satisfaction, organizational resilience, and long-term competitive advantage in the increasingly digital and virtualized workplace.

Limitations and Future Directions

This study makes several important contributions but also presents conceptual, contextual, and methodological limitations that open promising avenues for future research.

First, although our study adopted the Six E-Competencies Model (Roman et al., 2019) to assess digital leadership, the model may not fully capture the evolving nature of leadership in dynamic digital ecosystems. As organizations embrace artificial intelligence, automation, and hybrid work structures, future research should examine how digital leadership competencies evolve, adapt, and integrate with emerging technologies. This aligns with the call by Benitez et al. (2022) to reconceptualize digital leadership capabilities as organizations undergo continuous digital transformation.

Second, our treatment of knowledge sharing (KSH) as a mediator focused on intellectual exchange. However, KSH can also be shaped by factors such as psychological safety, team climate, or leadership style. Future studies could investigate boundary conditions or moderators like organizational trust, team diversity, or virtual team structure that influence the effectiveness of DLCs in facilitating knowledge exchange.

Third, while we positioned happiness at work (HAW) as a mediator, it is also likely to function as a dynamic outcome or moderator in other team contexts. Longitudinal research could assess how emotional well-being fluctuates over time in response to leadership interventions, digital overload, or cultural norms. This approach would offer a more nuanced understanding of the temporal role of HAW, especially in sustained virtual collaborations.

Fourth, although the SRMR index fell within acceptable limits, the d_ULS and d_G values exceeded recommended thresholds (Benitez et al., 2022), suggesting areas where our model may not fully account for data complexity. While our model is theoretically integrated, it is not unusually complex. A more likely explanation is our constructs' sample size and structural features, including relatively new applications of DLCs and HAW in virtual contexts. Future studies should validate these constructs using larger, more diverse samples and explore alternative modeling approaches, such as multi-group SEM or higher-order constructs, to improve model fit (Rigdon, 2016).

Fifth, our data's cross-sectional and self-reported nature introduces potential bias due to common method variance or social desirability. Utilizing multiple data sources, longitudinal designs, or time-lagged approaches would improve causal inference and model robustness (Bowen & Wiersema, 1999; Ployhart & Vandenberg, 2010).

Sixth, this study was conducted in Saudi Arabia, a context experiencing rapid digital transformation. Cultural values, digital maturity, and leadership norms may influence the generalizability of our findings. Future research could adopt cross-cultural comparisons to explore how national culture, industry differences, or platform readiness influence the effectiveness of digital leadership across global contexts.

Lastly, while we focused on knowledge sharing and happiness at work as mediators, other constructs such as trust, team cohesion, and organizational support may also explain how digital leadership impacts virtual team outcomes. Additionally, psychological safety may serve as a moderator in this relationship, helping to contextualize when and for whom digital leadership is most effective (Liu et al., 2016; Walumbwa & Schaubroeck, 2009).

This study opens several promising research directions across conceptual, contextual, and methodological domains. We encourage future scholars to expand this work by integrating emergent constructs, adopting longitudinal and cross-cultural approaches, and rethinking digital leadership frameworks in light of rapidly changing workplace dynamics.

CONCLUSION

This study, grounded in Social Exchange Theory (SET), elucidates the critical role of DLCs in enhancing virtual team effectiveness, mediated by knowledge sharing and happiness at work. Our findings provide compelling evidence that DLCs directly influence virtual team effectiveness and operate through these key mediators. This dual pathway underscores the importance of fostering DL skills to facilitate knowledge exchange and boost workplace happiness, thereby driving overall team effectiveness. These insights offer a refined understanding of leadership in the digital era and present actionable strategies for organizations to optimize their virtual teams' effectiveness through targeted interventions to enhance knowledge sharing and employee well-being.

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APPENDIX A: MEASUREMENT SCALES AND SOURCES

Virtual team effectiveness:		
Measurement items		**Source**
VTE 1 VTE 2 VTE 3 VTE 4 VTE 5 VTE 6 VTE 7 VTE 8	1. My team is currently meeting its business objectives. 2. I enjoy being a member of this team. 3. There is respect for individuals in my team. 4. I feel the members of my team value my input. 5. Team member's morale is high in my team. 6. In the past, my team has been effective in reaching its goals (x) 7. When my team completes its work, it is generally on time. 8. When my team completes its work, it is generally within the budget.(x)	Pangil, F., & Chan, J. M. (2014)

Knowledge sharing:		
Measurement Items		**Source**
KSH 1 KSH2 KSH3 KSH4	1. My team members share their ideas openly. 2. My team members are willing to share knowledge/ideas with others. 3. My team is good at using the knowledge/ideas of their members. 4. My team members with expert knowledge are willing to help others.	Staples & Webster (2008)

Digital leadership competencies:			
Measurement Items			**Adopted From**
E-Communication competency	DLC1 DLC2 DLC3	• In his/her virtual communication, the leader is clear, well organized, and allows for feedback to avoid errors and untested assumptions. • In his/her virtual communication the leader sometimes conveys unintended messages that leave the receiver feeling insulted or angry because of tone or misunderstandings.*(x) • The leader ensures that his/her virtual communication is not excessive to the point of impeding the ability of employees to get their work done. (x)	Roman et al. (2019)
E-Social competency	DLC4 DLC5 DLC6	• The leader does not provide employees sufficient individualized virtual communication.* (x) • The leader uses a rich variety of virtual communication methods. • The choices of virtual communication methods used by the leader improve communication and collaboration.	
E-Team competency	DLC7 DLC8 DLC9	• The leader is ineffective in building teams that are productive in a virtual mode.* (x) • The leader is able to motivate teams that operate primarily in a virtual mode. • The leader is able to hold teams that work in a virtual mode accountable.	
E-Change competency	DLC10 DLC11 DLC12	• The leader is effective in using virtual communications to plan organizational changes. • The leader is effective in using virtual communications to monitor organizational change. • The leader is effective in using virtual communications to evaluate change initiatives.	

E-Tech competency	DLC13 DLC14 DLC15	• The leader does not stay abreast of new information communication technologies (ICTs) and new enhancements of virtual communications.* (x) • The leader has sufficient skills and inclination to deal with various types of technology breakdowns in both personal and enterprise settings. • The leader is aware and active in terms of cyber-security efforts.	
E-Trust competency	DLC16 DLC17 DLC18	• Within the virtual environment, the leader is able to create a sense of trust. • The leader uses virtual communications in a manner that supports honesty, consistency, follow-through, fairness, and general integrity. • The leader ensures that support of diversity is present and well monitored in virtual settings. (x)	

Happiness at work:		
Measurement items		**Source**
HAW 1	1. At my work, I remain inspired and try to inspire others as well. My organization provides all necessary training and information to complete work on time.	Singh & Aggarwal, (2018)
HAW 2	2. I feel internally driven to do great things at my work.	
HAW 3	3. I enjoy what I am doing at work.	
HAW 4	4. I am not very comfortable in approaching my leader*	
HAW 5	5. I feel stressed at work*	
HAW 6	6. Often, I feel like quitting my job*	
HAW 7	7. My organization provides all necessary training and information to complete work on time.	
HAW 8	8. The decision-making process in my company is fair and just.	
HAW 9	9. Top leaders of my organization have clear vision and focus.	
HAW 10	10. My organization does not have proper guidelines to regulate team behaviour and work that require collective effort.* (x)	
HAW 11	11. My company does not have a proper interface that can allow us to work for social cause.* (x)	
HAW 12	12. I don't get sufficient credit for my contributions. *	

Note: * Denote the negatively worded items of the scale. x= removed items

Attitude toward the color blue:	
Measurement Items	**Source**
1. Blue is a beautiful color.	Miller & Simmering, (2023)
2. Blue is a lovely color.	
3. Blue is a pleasant color.	
4. The color blue is wonderful	
5. Blue is a nice color.	

6. I think blue is a pretty color	
7. I like the color blue.	

Demographic	
Gender	Male Female
Age	21 to 29 years old 30 to 39 years old 40 to 49 years old 50 to 59 years old 60 years and above
Education	High school Bachelor Master PhD Others ----------
Working experience	Less than 1 year 1 to 5 years 6 to 10 years 11 to 15 years 16 to 20 years More than 20 years
Working experience in virtual team	Less than 1 year 1 to 5 years 6 to 10 years 11 to 15 years 16 to 20 years More than 20 years
Current working sector	Private Public
Have you ever been a virtual team leader?	Yes No