Towards a Better Microlevel Understanding of the Use of Emerging Technologies at Work: The Interplay Between Virtual Teams, Knowledge sharing and Innovation Output

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Abstract

The COVID-19 pandemic has forced many organisations to make an unprecedented shift to remote work, with virtual teams becoming an increasingly important tool for organisations to configure and manage team-based work. The way teams are configured has major implications for how individuals, teams and organisations collect and contribute knowledge in order to innovate. By looking at team member diversity, this research paper examines the impact of different forms of diversity on the knowledge sharing processes and innovation output of virtual teams. Responses from 103 virtual team members based in the UK are used to assess the role of diversity inputs, on knowledge sharing processes and innovation output. PLS SEM was employed to assess and validate the IPO (input-process-output) model with statistically significant empirical results presented. Furthermore, the empirical results infer that knowledge sharing plays a critical role in mediating the role between diversity and innovation output in virtual team settings. Findings are discussed and implications are presented.

Keywords: Microfoundations, Emerging Technologies, Virtual Teams, Innovation, Knowledge Management, Knowledge sharing

1. Introduction

The COVID-19 pandemic has forced organizations around the world to adapt how they organize their teams to continue operating under government restrictions. The Office of National Statistics reported that 46.6% of employed people in the UK were working from home full-time by April 2020, one month into the restrictions [1]. With widespread social distancing and lockdowns, many organizations made the unprecedented shift to digitalization and remote work [2]. Virtual work opens up a host of new opportunities and challenges for organizations and those managing teams [3].

Virtual teams are groups characterized by four main components: their members and organization recognize them as a team [4], they are geographically dispersed [5], they use computer-mediated communication (CMC) to collaborate and coordinate across space and time [6], and they drive toward a common goal [7]. Similar to their co-located counterparts, virtual teams are assembled by organizations to use human resources to assist and contribute to the realization of composite functions and irregular activities [8]. When integrated effectively into organizations, virtual teams offer a host of productivity and performance-related benefits, forming collaborative networks and knowledge-based systems that help organizations innovate [9].

In recent years, with stronger communication technologies, virtual teams have become an increasingly popular way for organizations to configure and manage team-based work. With the accelerating globalization of work and the rise of CMC, many organizations are turning to virtual teams to bridge complex gaps in ‘space over time’ [10] [11]. Virtual teams are considered a micro-foundation, referring to the idea that macro-level phenomena (e.g., an entire organization) can be understood by examining the individual actions and interactions within these teams; while they can be part of

micro-level analysis, virtual teams also create opportunities for organizations, bridging geographical, temporal, and organizational boundaries and enabling access to a global talent pool. Thus, they play an important role in both social and economic spheres for professionals, organizations, and nations [12] [6].

Individual members' diversity has implications for the cohesion of teams, with the potential to impact a team's ability to work together, share knowledge, and bring benefits to organizations through innovation [13]. Virtual teams are often comprised of individuals from a range of backgrounds, who connect across these boundaries to make decisions with far-reaching strategic implications for organizations [14]. Diversity in virtual teams has been hailed for bringing together new, and sometimes conflicting, styles, attitudes, and modes of thinking, posing new opportunities and challenges for how knowledge and decision-making are integrated into team settings [15]. Therefore, understanding the flow of the system through which diversity impacts knowledge-sharing processes and innovation output is a primary objective of this research study [16]. Prior research focusing on virtual teams has highlighted the importance of trust in team effectiveness, shedding light on the challenges that virtual settings pose for relationship-building [6]. Other studies have examined leadership, success-measuring, and team processes in virtual teams [17]. Notable contributions have also been made on the topics of diversity, knowledge-sharing, and team performance [4].

The main objective of this research was to investigate the impact of team members' diversity on knowledge-sharing and innovation in virtual teams in the global post-pandemic context through a micro-level lens. Therefore, we aimed to build on the extant literature by examining how diversity, knowledge-sharing, and innovation intermingle. Second, we examined the 'doubled-edged sword' of diversity [18] by investigating this

among team members in virtual team settings. This study offers new empirical evidence and a framework to support businesses in managing diversity in virtual teams, in turn attaining effective communication and collaboration in diverse virtual teams. It contributes to the literature by providing an empirical study on how inputs of diversity impact the knowledge-sharing process in virtual teams within the context of the COVID-19 pandemic.

Following this introduction, section two provides a comprehensive review of the literature, highlighting the gaps that the study addresses. This is followed by the hypothesis development, then section three, which outlines the methodology, including the research design, data collection, and methods. Section four presents the main findings of the study, and section five discusses the implications of the findings and provides recommendations for future research. Finally, the main conclusions and key contributions of the study are summarized.

2. Literature review

Virtual teams

Virtual teams are defined as geographically dispersed teams, using technology to collaborate, communicate, and coordinate, in the pursuit of common goals [12] [6] [19]. Virtual teams have been recognized as bringing particular benefits to organizations that co-located teams cannot. One example is the ability to select from a global talent pool, allowing organizations to bring together the best talent, regardless of location [20] [21] [22] [23] [24]. This ability to source global talent can bring major benefits for organizations and often leads to increased diversity in team members' experiences, attitudes, and skills.

Pinjani and Palvia [25] note that minimal face-to-face interaction, a consequence of virtual settings, can lead to breakdowns in the contributions and collaborative capabilities of team members, causing projects to suffer. Several reoccurring causes are noted in the literature, including geographical, temporal, and cultural distances; language barriers; and interpersonal conflicts [12] [6]. Other literature acknowledges these issues but draws opposing conclusions, implying that though with fewer opportunities for direct interaction, virtual teams develop a more inclusive environment that respects and accepts members' differences [12]. The literature has focused on trust and knowledge-sharing as two central components of effective virtual teams [8] [26]. Studies have tended to examine the importance of trust and accountability in virtual teams, measured through team satisfaction [27] [28]. One of the biggest gaps identified and a goal of this study to examine is how virtual teams can effectively and efficiently coordinate, collaborate, and communicate to contribute knowledge and innovate.

Virtual team member diversity

Diversity in virtual teams creates both opportunities and challenges for how members interact, share information, and leverage team knowledge as a strategic resource; . Diversity in the virtual team space has divided academics; "often the relationship is neither simple nor direct" [4, p. 145]. On one hand, diversity is lauded as the answer to creativity, enhancing knowledge-sharing between individuals, teams, and organizations [29]. On the other hand, disharmony and discord may be disseminated in virtual teams from too many opposing viewpoints, creating social categorizations of in-groups versus out-groups that lead to misalignment and work culture–related problems [6] [30]. As such, it is important to investigate micro-level diversity dynamics to offer a better understanding of the overall organization setting.

Diversity in individuals is treated across three main levels: surface, deep, and functional [31]. Surface-level diversity refers to demographic differences between team members (e.g., ethnicity, gender, age). Although all forms of diversity can impact teams, surface-level diversity is often treated as secondary due to the minimal face-to-face interactions of virtual team members [31]. In contrast, deep diversity is concerned with team members' attitudes, values, and beliefs [32], and functional diversity relates to differences in individuals' skills, knowledge, and ability [31]. Functional diversity has been visited by academics to reflect how diverse knowledge results in increased knowledge access and absorption within a team, leading to greater knowledge-sharing and innovation [12] [28] [33]. However, increased diversity also creates conflict between team members in both their relationships and day-to-day work output [31]. This study focuses on deep and functional diversity. Diversity is inherent in virtual teams due to their dispersed nature, crossing geographic, organizational, and institutional boundaries. Therefore, this study aimed to investigate the relationship of different types of member diversity with knowledge-sharing processes and innovation output in virtual teams.

Knowledge-sharing

Knowledge-sharing is a critical strategic resource for organizations and is pivotal in the effectiveness of virtual teams [12]. The power of all teams, virtual or co-located, is in their ability to bring together and blend knowledge, with the aim of communicating and transferring knowledge between individuals, the team, and the wider organization to achieve common goals [34]. Good understanding of how virtual teams exchange knowledge can shed light on broader organizational dynamics.

Knowledge has different definitions across the literature: either a process, state of mind, capability, or condition of having access to information [35]. Knowledge-sharing is a process that mediates the relationship between knowledge inputs, either external (customers) or internal (teams), and organizational output. Academics define knowledge-sharing differently for their purposes, resulting in the absence of a persistent, single definition in the literature. Hung et al. [12] define knowledge-sharing as the "process in which the knowledge source is encoded and provided, and the knowledge receiver acquires, decodes, and finally internalizes the knowledge" [12, p. 601]. Similarly, Hendriks [36] highlights the importance of acknowledging knowledge from at least two dimensions: the sharer and the receiver. Knowledge management systems are integral to managing the effective flow and use of knowledge and are core for innovating [37] [38] [39] [40].

Typically, knowledge is owned by the sharer, who donates knowledge to others, enabling them to access and use it [12]. Knowledge donation constitutes the dissemination of knowledge and provides the necessary tools to understand discrete and complex problems. For the receiver to identify, assimilate, and use valuable external knowledge for commercial purposes, they must incorporate it.

A host of research has noted that knowledge donation is integral for solving and spreading new knowledge, and knowledge incorporation is vital for bringing new knowledge into an organization [17] [39] [41]. Ultimately, knowledge-sharing underscores the significance of knowledge exchange in creating value [12].

Innovation

Vast research has been conducted on the relationship between virtual teams and innovation. Researchers have examined the effects of virtual teams on open innovation

in services [42], on processes [43], and on collaborative innovation and networks [44]. Conclusions vary on how virtual teams contribute to innovation output. On the one hand, the role of member diversity in virtual teams is assumed as a facilitator for innovation. Diversity in virtual teams provides a plethora of new knowledge, which can amplify and augment the quality and quantity of innovation output [45]. According to these authors, diversity also expands the knowledge base and creates the necessary knowledge to tackle problems in new and creative ways. However, heterogeneous virtual teams [46] often face challenges in collaborating and communicating, which can hinder their ability to consistently contribute to innovation and even slow or block the process. This indicates a gap in the literature concerning the role of deep and functional diversity in virtual teams to enhance innovation output [47].

Ali and Park [48] recognize three categories of innovation: product innovation, process innovation, and managerial and administrative innovation. Product innovation refers to the creation of new goods or services or the improvement of existing products [49]. Process innovation involves improving or developing new ways of producing, distributing, or delivering products or services [50]. Managerial and administrative innovation is concerned with improving the overall management of a company or organization [51]. Similarly, Hung et al. [12] group these three categories into two helpful heuristics: technical and nontechnical innovation. Technical innovation refers to product and process innovation, whereas non-technical innovation refers to managerial and administrate innovation. The extant literature has predominantly investigated technical innovation, but nontechnical innovation also remains a critical component [52].

Task interdependence

Task interdependence is described in the literature as the degree to which team members must interact to finalize a task. This refers to the extent to which they must rely on each other to accomplish their individual tasks and achieve the team's overall objectives [53] [54]. According to the existing research, high levels of task interdependence were associated with better team performance, particularly when team members had complementary skills and expertise [55]. Task interdependence is also reported to promote information-sharing among team members, in turn increasing team creativity and innovation [56]. Task interdependence largely depends on the type of task at hand. Research has shown that task interdependence is more beneficial for complex tasks that require diverse skills and knowledge, as opposed to simple tasks that can be easily completed by a single individual [57] [58] [59]. Moreover, the level can vary depending on the stage of the team's development. In the early stages, high levels of interdependence may be necessary to foster collaboration and coordination, but as the team matures and members become more familiar with each other's roles and responsibilities, the need for task interdependence may decrease [60].

Notably, task interdependence can be affected by various contextual factors, such as organizational culture, leadership style, and technology [61]. For example, a hierarchical organizational culture may discourage team members from engaging in collaborative behaviors, whereas a transformational leadership style may promote a shared vision and a sense of collective responsibility [62]. Task interdependence can also have negative effects on team performance because team members may have conflicting goals or priorities. High levels of task interdependence can thus lead to communication breakdowns and coordination difficulties [63] [64]. To mitigate these

negative effects, some researchers have proposed that team members must develop shared mental models and establish clear communication protocols to facilitate coordination and collaboration [65] [66].

Advances in communication technology have facilitated virtual teamwork, where team members are located in different geographical locations and rely on electronic communication to collaborate. According to Li, Mitchell, and Boyle [67], task interdependence is an essential aspect of knowledge-sharing in a virtual team context. Although virtual teams can leverage task interdependence to enhance performance, they also face unique challenges related to coordination, communication, and trust [68].

Hypothesis development

Diversity and knowledge-sharing

Knowledge-sharing is linked to how team members relate to each other, build trust, and collaborate [6]. The notion of teamwork is that individuals can coordinate and collaborate to achieve outcomes that would not be possible when working alone. Within this context, the literature suggests that team members must learn from each other and build similarities in interpreting and evaluating new forms of knowledge [69].

Deep-level diversity refers to the diversity of personal characteristics that are not immediately obvious in an individual's appearance [70] [71], whereas functional-level diversity relates to the experience and skills of team members. Milliken and Martins [18] suggest that groups can be diverse in multiple ways through non-observable characteristics, from differences in values to differences in experiences. Batarseh, Usher, and Daspit [31] state that deep diversity in "personal characteristics such as values, beliefs and attitudes are communicated through extended, personalised

interaction and information gathering" (p. 1344). This is a difficulty in virtual teams, where face-to-face interactions are minimal due to the high degree of text-based CMC (e.g., Slack, WhatsApp, Gmail) [6]. Research suggests that the more diversity in values and attitudes, the more likely that conflict will arise in team member relationships, contributing to misalignment in how they prioritize knowledge and interpret each other's actions [72] [73]. This indicates that team member diversity is likely to increase the difficulty in collecting and incorporating knowledge, while also limiting and disincentivizing knowledge donation between team members [74] [75]. Generally, this is likely to have negative associations with knowledge-sharing, creating friction in the process of sharing knowledge and lowering the collaborative qualities of teams [76]. Therefore, we hypothesized:

Hypothesis 1a: Deep diversity in virtual teams is negatively associated with knowledge incorporation.

Hypothesis 1b: Deep-level diversity in virtual teams is negatively associated with knowledge donation.

Hypothesis 1c: Functional-level diversity in virtual teams is negatively associated with knowledge incorporation.

Hypothesis 1d: Functional-level diversity in virtual teams is negatively associated with knowledge donation.

Knowledge-sharing and innovation output

Knowledge-sharing is integral to the establishment of strong knowledge flows, allowing for informal learning, collective understandings, and continuous communication within teams [76]. The knowledge donation of team members forms

the basis from which new knowledge is contributed to the team [77]. A growing body of literature explores the relationship between knowledge-sharing and innovation output, which has a significant positive impact on economic growth [78]. Informal knowledge-sharing is considered an integral aspect of learning in a team environment and has been investigated in the literature with a strong link to innovation [79] [80]. Knowledge-sharing has been found to have a significant positive impact on employees' technical innovation performance [81]. Similarly, Wang and Noe [76] suggest a positive association between knowledge-sharing and nontechnical innovation in a research and development organization. Knowledge-sharing among team members has been also found to have a significant positive impact on innovation output in software development projects (Hsu et al., 2007). Accordingly, Huang et al. [82] suggest a positive association between knowledge-sharing and innovation performance in a knowledge-intensive service industry. Wang et al. [83] suggest that knowledge-sharing positively impacts innovation performance and that knowledge management practices and organizational culture are critical drivers of knowledge-sharing.

Research has shown that knowledge-sharing can also enhance innovation by facilitating learning and problem-solving. For example, Xu and Chen [84] found that knowledge-sharing among employees in a high-tech company promoted their problem-solving ability, which in turn positively influenced their innovation performance. Similarly, Liu and Li [85] reported that knowledge-sharing facilitated learning among employees, which improved their innovation capability. The direction of knowledge-sharing also plays a role in its impact on innovation output. Knowledge donation, where individuals voluntarily share their knowledge with others, had a stronger positive effect on innovation output than did knowledge collection, where individuals seek out and collect knowledge from others [86].

As highlighted in the literature, knowledge-sharing in virtual teams is a two-way process. A team member(s) donates knowledge, and another team member(s) incorporates the knowledge donated. The ability to incorporate, collect, and absorb the knowledge being donated is integral to the process of knowledge-sharing and allows the transformation of knowledge from individual members to the team, enabling innovation output [12]. Prior studies indicate that the absorptive capacity of global virtual teams plays a positive role in innovation [31] [48] [87] [88]. Knowledge-sharing can enhance innovation by increasing the knowledge base and problem-solving capability of employees, as well as by promoting a culture of learning and collaboration within the organization. Thus, we hypothesized that:

Hypothesis 2a: Knowledge donation is positively associated with technical innovation.

Hypothesis 2b: Knowledge donation is positively associated with nontechnical innovation.

Hypothesis 2c: Knowledge incorporation is positively associated with technical innovation.

Hypothesis 2d: Knowledge incorporation is positively associated with nontechnical innovation.

The moderating effect of task interdependence

Task interdependence is a critical component of team performance, especially in virtual teams where members are geographically dispersed and have limited face-to-face interactions. The extent to which members interact and rely on each other to complete their tasks determines the level of task interdependence [89]. Prior research has identified task interdependence as having a moderating effect on the interaction

between knowledge-sharing and diversity [90] [91]. The higher the degree of task interdependence, the more tightly coupled the work is [6]. A high degree of task interdependence also suggests that members of the team rely on each other to complete tasks and is likely to lead to effective collaboration between members [53] [54]. As such, team members rely on each other and are encouraged to share information, resources, and knowledge to ensure a shared base from which to complete work [92]. While team members work together, they connect and coordinate; this means they understand the necessity to communicate and share knowledge to achieve goals and objectives [93]. Hence, when they have a high degree of task interdependence, they are more likely to donate knowledge to their teammates [94]. They can share their expertise and are more likely to solve problems and make better decisions, leading to better performance [95]. Equally, members are more likely to develop innovative solutions and improve team performance when they are open to new ideas and integrate them into existing knowledge structures [76] [96].

In virtual teams, where diversity might significantly affect knowledge donation, designing team structures and processes that promote task interdependence can lead to better performance by leveraging the positive effects of knowledge donation and incorporation and mitigating the negative effects of deep-level and functional diversity [97] [6].

Therefore, we hypothesized:

Hypothesis 3a: Task interdependence moderates the relationship between deep-level diversity and knowledge donation in virtual teams.

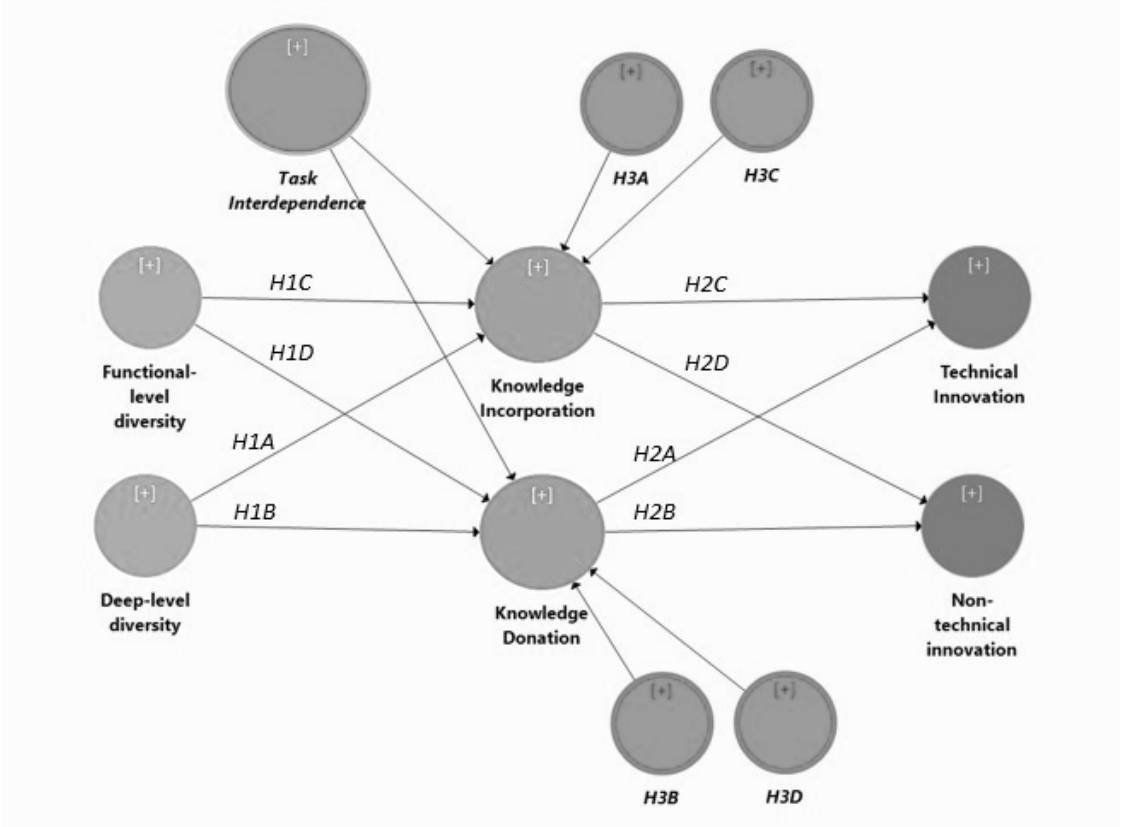
Hypothesis 3b: Task interdependence moderates the relationship between deep-level diversity and knowledge incorporation in virtual teams.

Hypothesis 3c: Task interdependence moderates the relationship between functional-level diversity and knowledge incorporation in virtual teams.

Hypothesis 3d: Task interdependence moderates the relationship between functional-level diversity and knowledge donation in virtual teams.

The relationships between constructs relevant to the study hypotheses are illustrated in the research model in Figure 1.

Figure 1: Research Model with Hypotheses



3. Methodology

Our research study employed a field survey and a non-probability sampling method. The study sample was limited to those based in the UK working in virtual or remote

teams, across multiple industries. We used a structured questionnaire, with the responses recorded on 5-point Likert scales. Functional and deep-level diversity measurement scales were taken from Pinjani and Palvia [25]. These two constructs corresponded to diversity and were treated as two separate independent variables. These constructs have been used to test diversity in virtual teams in other studies [31]. Knowledge-sharing and knowledge donation followed Hung et al. [12]. Similarly, technical innovation and nontechnical innovation measurement items were adopted from Hung et al. [12]. Task interdependence was used to test for a moderation effect in the relationship between diversity and knowledge-sharing. The task interdependence measurement scale consisted of three items taken from Campion, Medsker, and Higgs [53].

The online field survey used for this study was sent to 700 virtual team members on LinkedIn.com, with 103 responses representing a response rate of 14.71%. Among the 103 respondents, 42 were men (40.8%), and 61 were women (59.2%). They varied in age, with 16 respondents aged 18 to 24 years (15.5%) and four respondents aged 55 to 64 years (3.9%). Team sizes varied, with the majority ranging from 6 to 15 members (60.1%). Thirty-five respondents (34%) were working in teams distributed across one country. This is likely a residual effect of the COVID-19 pandemic. Of the sample, 48.5% were part of teams dispersed over three or more countries, showing the ability of virtual teams to transcend geographical boundaries. Out of all respondents, 38 (36.9%) were in face-to-face teams that turned virtual during the pandemic, and 28 (27.2%) were part of virtual teams before the pandemic. This was also reflected in the average tenure of virtual team members, with 78 (75.7%) having been in their virtual team for less than three years.

The partial least squares (PLS) structural equation model (SEM) was chosen to investigate and analyze our research model and test the hypotheses. PLS-SEM is a type of path analysis that allows for smaller sample sizes and considering both explanatory and dependent variables [98]. The Cronbach alpha ranged from .670 to .851, surpassing the .60 threshold [99]. We then employed composite reliability (CR) to check the internal consistency of constructs [100] [101] [102]. As seen in Table 1, our CR measurements ranged from .8181 to .8996 and were thus deemed acceptable. To test for convergent and discriminant validity and guarantee the validity of the structural model, we used the average variance extracted (AVE) [103]. Our constructs surpassed this threshold of acceptance, ranging from .550 to .717 (see Table 1).

Table 1: Reliability and Validity of Constructs

Construct	Construct type	Description	Cronbach A	Factor loading	CR	AVE
Functional-level diversity [91]	Reflective	1. Members of the virtual team are similar in terms of their educational backgrounds.	.809	.910	.883	.717
		2. Members of the virtual team are similar in terms of their functional expertise.		.799		
		3. Members of the virtual team are similar in terms of their length of organizational experience.		.827		
Deep-level diversity [91]	Reflective	1. Members of the team are similar in terms of their personal values.	.802	.722	.871	.628

		3. Members of the team are similar in terms of their attitudes toward the project.		.836		
		4. Members of the team are similar in terms of their attitudes toward the project goals.		.798		
		7. Members of the team like sharing information with my fellow team members.		.809		
Task interdependence [53]	Reflective	1. Members of the virtual team have to rely on information or material from others within the team to perform their tasks.	.792	.858	.873	.697
		2. Jobs performed by virtual team members are all related to one another.		.885		
		3. Members of the virtual team cannot accomplish tasks without information or materials from other members of the team.		.755		
Knowledge incorporation [12]	Reflective	1. In the virtual team, I can immediately obtain new knowledge required for work.	.670	.557	.818	.609
		2. I am capable of using knowledge obtained from the virtual team.		.875		

		3. I attempt to solve task problems through knowledge of the virtual team.		.874		
Knowledge donation [12]	Reflective	1. In the virtual team, we share working experience.	.720	.784	.827	.550
		2. In the virtual team, we share our professional knowledge.		.821		
		3. In the virtual team, I often share new information acquired with team members.		.773		
		4. In the virtual team, we share work reports and official documents.		.559		
Technical innovation [12]	Reflective	1. The virtual team can upgrade current product/service quality.	.830	.851	.887	.665
		2. The virtual team can develop new products/services.		.905		
		3. The virtual team can upgrade convenience of customers' use of products/services.		.749		
		4. The virtual team protects our rights, such as new patents or copyright.		.746		
Nontechnical innovation [12]	Reflective	1. The virtual team allows members of different positions	.851	.832	.900	.691

		(such as R&D and marketing) to demonstrate their advantages.				
		2. The virtual team can change executive procedure and process through new measures.		.856		
		3. The virtual team breaks through limitations of the workplace, resulting in brainstorming by members.		.814		
		4. The virtual team can change the present product/service design by new methods, such as change of appearance, packaging, form, or content.		.823		

4. Analysis and results

Our results indicate a statistically significant positive relationship between deep diversity in virtual teams and knowledge incorporation (H1a: $\beta = 0.4830$, $p < 0.01$. SE = 0.0819). Therefore, H1A was not supported. H1B also indicated a statistically significant positive relationship between team members' deep-level diversity and knowledge donation (H1B: $\beta = 0.6051$, $p < 0.0.01$, SE = 0.0752). H1B was not supported, in contrast to prior research, where a negative relationship has been established between deep-level diversity and knowledge-sharing [4] [31]. A possible explanation is that diversity in members' deep-level characteristics encourages alternative suggestions and solutions, helping teams to move away from the pitfalls of 'groupthink' and establish a positive environment and culture for knowledge to be

donated and incorporated by members [104]. H1C and H1D were also rejected due to a lack of statistical significance (H1C: $\beta = 0.0332$, $SE = 0.0722$, $p > 0.05$; H1D: $\beta = 0.0552$, $SE = 0.0558$, $p > 0.05$). Hence, the moderation hypotheses H3C and H3D were not tested.

The results supported hypotheses H2A and H2B and indicate a strong, positive effect between knowledge donation and both technical and nontechnical innovation (H2A: $\beta = 0.3329$, $p < 0.01$, $SE = 0.1042$; H2B: $\beta = 0.4224$, $p < 0.01$, $SE = 0.1386$), in agreement with previous studies [12] [104]. We also found a positive and statistically significant relationship between knowledge incorporation and both technical and nontechnical innovation (H2C: $\beta = 0.2866$, $p < 0.05$, $SE = 0.1135$; H2D: $\beta = 0.3734$ $p < 0.01$, $SE = 0.1084$). This supports both H2C and H2D, in line with prior studies [12] [31] [105].

The moderations pertaining to H3A and H3B were examined using the product indicator approach, which estimates the effect of latent construct interactions in SEM [106] [107]. Both hypotheses were supported, agreeing with part of the extant literature [108] [91] and conflicting with some contradictory findings [e.g., 109]. Our results showed a statistically significant positive interaction (H3A: $\beta = 0.2195$, $t = 2.8075$, $p < 0.01$), such as with high task interdependence, the positive relationship between deep-level diversity and knowledge incorporation is strengthened. In low task interdependence, the interaction of the relationship between deep-level diversity and knowledge incorporation was weaker. Similarly, our results for task interdependence as a moderator of deep-level diversity and knowledge donation were statistically significant and implied a positive moderating effect (H3B: $\beta = 0.\ 0.1436$, $t = 2.1002$, $p < 0.05$). High task interdependence (i.e., tightly coupled work) strengthened the positive

relationship between deep diversity and knowledge donation. In low task interdependence, this interaction was weaker.

5. Conclusion and discussion

In an ever-changing world, diversity in thinking, attitudes, and values remain helpful tools for teams and organizations in understanding different perspectives and integrating them into different innovation projects. Organizations must be highly adaptive to succeed; therefore, the ability to use diversity—in skills, values, or attitudes—is vital. This study aimed to investigate the role of different types of team member diversity in knowledge-sharing processes and innovation output in virtual teams. It contributes to the literature by providing new empirical evidence from UK-based virtual team members on the relationships between deep diversity, knowledge-sharing, and innovation. This investigation is imperative in the post-pandemic context and with the rise of virtual working, with an evident need for updating the literature surrounding virtual teams. The study results have significant implications for researchers, practitioners, and policymakers.

A. Theoretical implications

First, our results imply that deep diversity among team members is positively related to knowledge-sharing. This deviation from previous findings advances the understanding of the role of deep diversity in virtual teams and confirms the need to explore these constructs further across new settings. Second, our research confirms that task interdependence is effective in strengthening the positive relationship between deep diversity and knowledge-sharing. Prior research has established this connection in different contexts [4]. Third, our results imply strong links of knowledge donation and incorporation with technical and nontechnical innovation, respectively. This bridges

the gap between diversity among virtual team members and teams' innovation output, contributing to a robust understanding of the importance of knowledge-sharing, especially for organizational nontechnical innovation. Therefore, our research also suggests that deep diversity among members does not obstruct virtual teams; instead, these differences help teams incorporate new attitudes and perspectives that complement their ability to absorb and contribute knowledge effectively.

B. Practical implications

Our findings have significant implications for practitioners. For those managing virtual teams, we recommend focusing on measures and policies that integrate deep-level diversity and encourage knowledge-sharing. Managers must recognize that diversity isn't only about superficial or even demographic differences. Deep diversity refers to diversity in thinking, attitudes, and values. Managers should foster an environment where diverse views are welcomed and respected and ensure that all team members feel valued for their unique perspectives. This form of diversity at the micro-level leads to better knowledge sharing, contributing to overall innovation. At the microfoundational level, managers should promote the idea of knowledge donation and focus on creating a collaborative environment that promotes knowledge-sharing among virtual team members. To facilitate this, managers could provide micro-level opportunities for virtual team members to connect and collaborate, such as through virtual meetings, video conferences, or online communication tools. In addition, managers should consider incorporating micro-incentives or recognition programs that reward virtual team members for sharing their knowledge or contributing to innovations. Managers must also understand that knowledge-sharing is not limited to technical knowledge but can also include nontechnical knowledge, such as knowledge about team dynamics or

communication strategies. Therefore, they should encourage a culture of openness and inclusivity, where virtual team members feel comfortable sharing and using both technical and nontechnical knowledge. Overall, creating a culture of knowledge-sharing in virtual teams can help organizations to innovate and improve their performance, both technically and nontechnically, despite geographical barriers. Managers must look for greater diversity in attitudes and experiences to help virtual teams avoid the pitfalls of groupthink, which create a cacophony of sameness in addressing problems, resulting in low or poor innovation output. As virtual teams become more common, managers need to understand how micro-interactions within these teams differ from those in traditional, co-located teams and seek to foster an environment where output, successful or not, is a reflection on teams and not individuals [4].

Governments and policymakers should encourage and invest in initiatives that promote knowledge-sharing and innovation, both technically and nontechnically. This could include supporting research and development programs, providing funding for innovation centers, and creating policies that incentivize knowledge-sharing and collaboration at the individual level within organizations. Policymakers should also focus on developing policies aimed at fostering a culture of respect for individual differences, and educational programs that teach individuals the skills necessary to contribute to innovation and knowledge-sharing in their fields. In addition, policies that promote diversity and inclusivity can be effective in fostering innovation by bringing together individuals with diverse perspectives and backgrounds.

6. Limitations and suggestions for future research

One limitation of this study is attributed to the sample, in terms of both size and profile. We obtained 103 valid responses, which may not fully represent the entire population of virtual team members. Another limitation is found in the approach to analyzing our research, which was solely quantitative. Future research into virtual teams is likely to benefit from a multi-group analysis, contributing to a richer understanding of the impact of team structure and demographics when examining team member diversity on knowledge-sharing and innovation in virtual settings. Additionally, future researchers may contribute to the literature by measuring team member responses across time intervals to track longer-term trends and issues when addressing deep-level diversity in virtual teams. Academics should continue to focus on CMC technologies to further understand how these can improve the relationship between deep-level diversity and team cohesion [6] [12] [31].

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