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How HRM and knowledge sharing technologies foster virtual team productivity for globally dispersed workforces: A systematic review

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ABSTRACT

Purpose – Virtual Team (VT) productivity is affected by multiple factors, including knowledge sharing, communication and collaboration due to geographical or temporal dispersion. This review spans multiple VT contexts globally to determine the practices that contribute to productive VTs. The authors fill a research gap by exploring how, across cultures and contexts, VTs overcome temporal and geographical dispersion barriers to share knowledge and foster productivity.
Aim – To reveal and understand critical factors that enhance virtual team productivity across multiple sectors and geographical boundaries.
Design/methodology/approach – The authors conducted a systematic review of twenty-one articles, which resulted from a comprehensive database search and quality screening of the best available evidence. Inductive thematic coding was used to conduct a mixed-method synthesis of findings across these studies.
Findings – Proper implementation of HRM practices combined with the utilization of technology tools that best fit tasks based on temporal and geographical needs can help organizations overcome dispersion issues among virtual teams.
Limitations of the study – Due to limitations of available evidence, this systematic review could not address all possible contexts. As a result, applying these findings across the broadest range of geographic areas and industry sectors should be exercised cautiously. Additionally, a small number of included articles were conceptual papers of relatively lower academic rigor.
Practical implications –This study highlights the importance of implementing HRM policies related to hiring, induction, training, and on-going appraisal practices to encourage knowledge sharing and build trust and socialization among teams.
Originality/value – By synthesizing evidence across various sectors and geographic boundaries, this paper provides rigorously supported recommendations for increasing VT productivity.

KEY WORDS

virtual teams, telework, human resources management, knowledge sharing, knowledge management

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1 INTRODUCTION

Few could have predicted how a global pandemic in 2020 would accelerate the transition to mobile working. According to GlobalWorkplaceAnalytics.com (2019), approximately 40% of the workforce worked remotely (i.e., at home or another location besides the company office) with some frequency before the global pandemic caused by the coronavirus-related illness known as COVID-19. Radocchia (2018) predicted that up to 50% of the workforce would soon move to remote working. However, due to COVID-19, employees around the world have been thrown into a massive telework experiment. Many of these people and organizations are new to working remotely and have struggled to maintain productivity. Virtual teams (VTs) and global virtual teams (GVTs) are teams that work together on shared goals but are dispersed either geographically or temporally and use technology tools to communicate (Gibson & Cohen, 2003; Zakaria et al., 2004). In parallel, workers the world over are now required to learn new technology tools that can help them break the barriers of time and location to remain productive, collaborative, co-creative and provide an environment conducive to continuous improvement. To aid managers in implementing

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effective tele-working, the following research question was formulated: *How do virtual teams overcome geographic and temporal dispersion issues to share knowledge and maintain productivity?* This article explores specific methods organizations can use to help virtual teams maintain productivity through knowledge sharing. Key factors surfaced in human resources management (HRM) practices and getting the right fit between tasks and technologies.

Research proves the monetary benefits of virtual offices. For example, companies with 5000 or more employees who mandate one day of telework per week and institute desk-sharing can save up to $14.8 million annually on facilities costs (Citrix, 2010). The data further shows that approximately 73% of those with flexible work arrangements (FWA), which includes working virtually, express agreement that FWA increases their satisfaction with their jobs (Malone University, 2019). Therefore, the conclusion was made that this can mean potential savings of $15 million in attrition costs and replacing dissatisfied workers (Citrix, 2010). The 2020 pandemic forced many organizations into working virtually, which escalated the need for these organizations to address productivity in a remote or virtual environment. This need is further related to the perceived barriers to performance in a virtual environment and how to overcome these perceived barriers. Productivity is defined as a measure based on the ratio of input and output, such as the relationship between time and resources spent to design and develop. Productivity is also related in the literature to the concepts of "efficiency" and "effectiveness" (Bosch-Sijtsema et al., 2009, p. 536) as well as creativity and creative output (Capece & Costa, 2009). Researchers in 2013 found that "project team dispersion is negatively associated with project performance. In other words, project teams that are widely dispersed across different locations are more likely to exhibit lower levels of project quality, on-time completion rate, and longer cycle times" (Bardhan et al., 2013, p. 1479).

On the contrary, in one study on European knowledge-intensive workers, van der Meulen et al. (2019) mentioned that dispersion could have productivity benefits, including increased privacy and fewer work interruptions. Further, website development teams in Italy were found to increase creative output through careful moderation of technology for internal communications and team coordination (Capece & Costa, 2009). Thus, a gap is observed concerning knowledge of what factors and practices contribute to productive VTs across cultures and contexts. This paper explores how VTs overcome temporal and geographical dispersion barriers to share knowledge and foster productivity by systematically synthesizing findings across several geographical and work contexts. By analyzing these diverse contexts and locations, this study aims to be impactful on a global level. The systematic review analyzed and synthesized twenty-one scholarly articles that span several countries, continents, and business sectors to reveal factors and strategies for organizations to enhance VT productivity through knowledge sharing. Viewed singularly, each article points to various disconnected factors. However, when synthesized, stronger threads and connections can be made, leading to a conceptual model for crucial factors and strategies to enhance VT productivity despite temporal or geographical dispersion.

2 BACKGROUND

VTs first entered the scholarly literature in the mid-1990s. VTs provided the flexibility that businesses needed to compete effectively (Mowshowitz, 1997, p. 67). During this period, researchers compared VTs with in-person teams and found that VTs displayed higher satisfaction levels (Warkentin et al., 1997). Several positive outcomes were cited in the literature during this period. Researchers established trust as a critical antecedent to the effectiveness of VTs (Iacono & Weisband, 1997; Jarvenpaa et al., 1998; Jarvenpaa & Leidner, 1999). Townsend et al. (1998) were among the early pioneers who linked knowledge sharing and effective communication with the success of VTs. Zakaria et al. (2004) confirmed this observation by noting that "the ability to create a knowledge-sharing culture within a global virtual team rests on the existence (and maintenance) of intra-team respect, mutual trust, reciprocity, and positive individual and group relationships" (p. 15). In contrast, the literature has also highlighted the negative outcome of the VT environment, as posited by Arora et al. (2010). The proliferation of VTs presents obstacles to effective knowledge sharing, pertaining mostly to communication and coordination.

Over the past 20 years since VTs first showed up in the scholarly literature, researchers have noted several problems related to this working style. These problems have primarily been revealed as issues related to HRM and technology tools for solving communication and collaboration issues. For example, problems with managing VTs are amplified due to temporal and geographic dispersion (Guzmán et al., 2010, p. 430). Due to such issues' pervasiveness, researchers have tended to focus on trust and technology. Sénquiz-Díaz and Ortiz-Soto (2019) investigated the trends in virtual team literature between 2008 and 2018, finding that the majority of researcher attention has been focused on behavior and communication, while "knowledge management issues in VTs have hardly been investigated" (p. 88). While some individual researchers have explored this area, this systematic review fills a research gap by combining findings from several different geographical and work contexts to provide insight into critical factors to knowledge sharing that improve VT productivity.

Knowledge sharing is a key factor related to the productivity of VTs (Bosch-Sijtsema et al., 2009; Mesmer-Magnus & DeChurch, 2009; Zakaria et al., 2004) and "knowledge has been recognized as an asset for the competitive

advantage of organizations" (Sénquiz-Díaz & Ortiz-Soto, 2019, p. 88). Donnelly and Johns (2020) found via a systematic review that remote working can result in dehumanization, which can negatively affect organizational knowledge sharing and exchange. Johnson (2020) observed that knowledge sharing is critical to "team heterogeneity" and "tacit knowledge held by team members." This observation is critical in understanding that "shared knowledge bases" are not "static" communal pools of knowledge (p. 64). The advantage of knowledge sharing was further posited by Johnson (2020): "knowledge sharing strengthens existing professional knowledge, enhances internal work coordination and consistency in employees' behavior, and effectively integrates diverse team knowledge and experience" (p.69). This supports the idea of VTs being diverse sources of knowledge and background, both from a cultural and educational standpoint. Further, knowledge sharing is a critical factor in generating enhanced productivity that provides a sustainable competitive advantage.

2.1 THEORETICAL FOUNDATIONS

The concern around productivity and barriers associated with teams working in a virtual environment led the researchers of this paper to examine theoretical constructs that could influence this study's variables. Therefore, after several theories were examined, it was determined that two theories would be utilized to underpin the research study, Media Synchronicity Theory (MST) and Task Technology Fit Theory (TTFT). Dennis et al. (2008) defined MST as a state of individuals collaborating simultaneously with a common focus. MST is focused on media in support of synchronicity. Selecting the type of media to use based on the intended purpose and form of communication enhances the quality and quantity of communication. An essential construct in this argument is that some communications are meant to convey information (conveyance communication), whereas others are meant to converge viewpoints to foster decision making (convergence communication). Therefore VTs, unlike collocated or in-person teams, are forced to select a communication medium that matches the purpose of the VT and should also support the team's efficiency while overcoming the barriers of temporal and geographical dispersion. TTFT was chosen because it was viewed as complementary to MST, emphasizing the need for a common medium to support collaboration and synchronicity in VTs. TTFT (Goodhue & Thompson, 1995) hypothesizes that the technology tools' fit impacts job performance and effectiveness to the specific tasks. Fit consists of eight factors: (1) Quality; (2) Ease of use or training; (3) Production timeliness; (4) Compatibility; (5) Locatability; (6) Systems reliability; (7) Authorization, and (8) Relationship with users. Both MST and TTFT were used to underpin this research study. The two theories provide a lens through which to view and analyze the primary factors that contribute to knowledge sharing among VTs and examine how and when productivity is enhanced in the VT environment.

3 METHODOLOGY

The methodology employed for this study is a systematic review grounded in evidence-based management research (Gough et al., 2012). The systematic review aimed to examine the research question: *How do virtual teams overcome geographic and temporal dispersion issues to share knowledge and maintain productivity?* Evidence-based research is the result of seeking the best available evidence from scholarly literature. Systematic reviews are literature-based reviews that employ scientific methods to avoid systematic error or bias. This is done by identifying, appraising, and synthesizing all relevant articles to answer or inform a research question (Petticrew & Roberts, 2006). Briner et al. (2009) further remarked that systematic reviews have become fundamental to evidence-based practice and represent a critical methodology for locating, appraising, synthesizing, and reporting "best evidence" (p.24). This qualitative research methodology presents a rigorous and transparent overall review process (Dixon-Woods et al., 2005). While singular studies can be informative for one particular context or intervention, managers can benefit from a complete picture of the evidence, synthesizing multiple sources of evidence. Thomas and Harden (2008) noted that qualitative research is often not generalizable due to specificity for a particular context, time period, or population. This study provides a broader picture of how the findings answer the research question through a synthesis of findings from multiple contexts, sectors, populations, and study designs.

The researchers for this study used the following methodology: (1) Developed a research question using the CIMO (Context, Intervention, Mechanism, Outcome) framework; (2) Established search criteria for inclusion and exclusion of peer-reviewed articles; (3) Designed several search strings using key variables to search for peer-reviewed literature and applied exclusion and inclusion criteria as part of the search strings; (4) Screened retrieved studies by reviewing abstracts that may potentially answer the research question; (5) Applied inclusion/exclusion criteria using the variables in the research question to determine which articles would be appraised for use in the research study; (6) conducted inductive thematic coding of included articles; and (7) analyzed and synthesized coding across themes and articles to generate findings and recommendations.

3.1 SEARCH

The researchers utilized over 50 scholarly databases, including Academic OneFile; Academic Search Ultimate; Business Insights: Essentials; Business Source Complete; Emerald Insight; Scopus; JSTOR and ProQuest. ABI/INFORM database was also explored. See Appendix A to view related Boolean search strings.

The results of the exhaustive search of peer-reviewed literature are captured in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) diagram. The diagram allows a graphical depiction of reporting and evaluating literature and includes four phases: 1) Identification; 2) Screening; 3) Eligibility; and 4) Inclusion (Moher et al., 2009, p. 334). See Appendix B for the PRISMA results of articles chosen for the study. Inclusion and exclusion criteria were set based on the research question, including years 2006 through 2019 and peer-reviewed articles from "anywhere" for this research. The year 2006 was the starting point for this study due to the lack of availability and affordability of collaboration tools prior (Bonk, 2020). Curlee and Gordon (2004) also contended that virtual teams did not need "state of the art technology...for success", with further observation that no research was "found that supported the need to have state of the art equipment" in the virtual team context. High quality synchronous and asynchronous VT collaboration requires relatively easy to use, highly functional, accessible, and affordable software tools. While CU-See Me, Webex, and some other net-based videoconferencing systems existed before 2006, many systems suffered issues of access and affordability, and their functionality was limited (Bonk, 2020). The year 2006 marked the entry of Polycom's first high-definition video conferencing system and a turning point concerning synchronous videoconferencing tools. The entry of Twitter and other Web 2.0 tools in 2006 ushered in an era in which all types of companies could afford and have easy access to highly functional software tools. After removing duplicate studies, the researchers performed a cursory review of the 295 non-duplicate article titles and abstracts, of which 258 articles were removed due to irrelevance to answer the research question. Many articles discussed one or more search teams without the correct context or outcomes pertinent to this study. The full texts of 37 articles were next reviewed. Studies pertinent to VTs, knowledge sharing, and collaboration with connection to productivity were included. Excluded articles included those outside of VTs, not factoring in aspects of productivity or articles involving studies conducted solely with education-related student groups.

3.2 APPRAISAL

The twenty-one articles that resulted from the search were reviewed in full and critically appraised to determine the research question's validity and relevance level. The appraisal was based on the Transparency; Accuracy; Purposivity; Utility; Propriety; Accessibility, and Specificity (TAPUPAS) (Pawson et al., 2003) for each article. The researchers aimed to compare each article's reporting, fitness to answer the specific research question, and overall utility as a piece of evidence. This appraisal helped inform the researchers by providing a weight or score to the evidence, based on each article's qualities. Such weight is factored into the overall assessment of the findings' synthesis in terms of importance to answer the research question. After the quality appraisal was conducted, the result was a final primary data set to be utilized in the study. The authors deemed 21 articles fit for inclusion in the primary data set. These articles were then coded to extract findings for analysis to answer the research question.

3.3 CODING

Coding is the process of extracting study findings into codes, which are categorized, analyzed, and summarized into themes. The authors conducted inductive thematic coding of 21 articles using Dedoose software and analyzed the results using spreadsheets and data visualizations to identify common and recurring themes through thematic synthesis (Gough et al., 2012). The coding process involves a first and second cycle along with analytic memoing. Saldaña (2016) stated that with first cycle coding "several of the individual methods overlap and can be mixed and matched" (p.80). Articles were also coded using "Hypothes.is" (https://hypothes.is), an open-source web annotation software extension that allows highlighting and tagging excerpts across articles. The codes were then loaded into a spreadsheet for further analysis in a second cycle. Second cycle coding involves "the researcher [revisiting] passages of text and edits, re-wording or regrouping emergent codes where necessary." Saldaña (2016) mentioned that second cycle coding serves the purpose of developing "a sense of categorical, thematic or conceptual from the array of first cycle codes" (p.234). The second cycle coding enabled the categories to emerge from the twenty-one articles. Eventually, these categories would help formulate the themes, which would begin to take shape at the end of the coding exercise. This process revealed descriptive and analytical themes across the research study articles.

Common codes and tags helped the researchers observe commonality across articles, which helped synthesize the research findings. Analytic memoing was another coding strategy used for this paper. Birks et al. (2008) mentioned that qualitative research emphasizes contextually situated meaning, and the act of "[m]emoing enables the researcher to engage with the data to a depth that would otherwise be difficult to achieve" (p. 69). Analytical

memoing is a mechanism to steer the researcher through all coding phases, from the "conceptualization to completion." Analytic memoing is the transitional process from coding to the study's formal write up (Saldaña 2016, p.54). This facet of the analysis is crucial to ensure the research is rigorous and can stand up to scrutiny from a quality perspective. The coding results are findings to support the nature of productivity of VTs and the types of HRM and technology tools needed to support VTs and answer the research question. These findings are discussed in the next section of this research study.

4 FINDINGS

The findings of this systematic review are the result of analysis and synthesis of inductive thematic coding of 21 articles that span multiple cultural contexts, countries, continents, sectors, industries, and study designs to answer the research question: How do virtual teams overcome issues of geographic and temporal dispersion to share knowledge and maintain productivity? These results include evidence from global software teams, technology companies, new product development (NPD) teams, knowledge workers, business consulting teams, inter-organizational project teams, and business school alumni from many countries across Europe, Asia, and North America. Two of the included authors (Guzmán et al., 2010; Montoya et al., 2009) conducted studies across forty-eight countries. A detailed listing of the contexts, populations, study designs, and countries can be found in Appendix C, Table 1C.

After an analysis of the primary data utilizing coding, two primary theme categories surfaced. They were: (1) Human Resources Management (HRM) practices and (2) Technology Tool Selection. A breakdown of the coding analysis revealed the following: (a) Three articles featured HRM practices prominently; (b) Eight articles featured technology tool selection, and (c) 10 articles jointly featured the two major finding categories. Table 1 is an overview of the articles and connections to the findings. See Appendix C, Table 1C for more details on the findings and relationship to variables in the research question.

Table 1: Results of Research Findings and Connections and Interrelationships

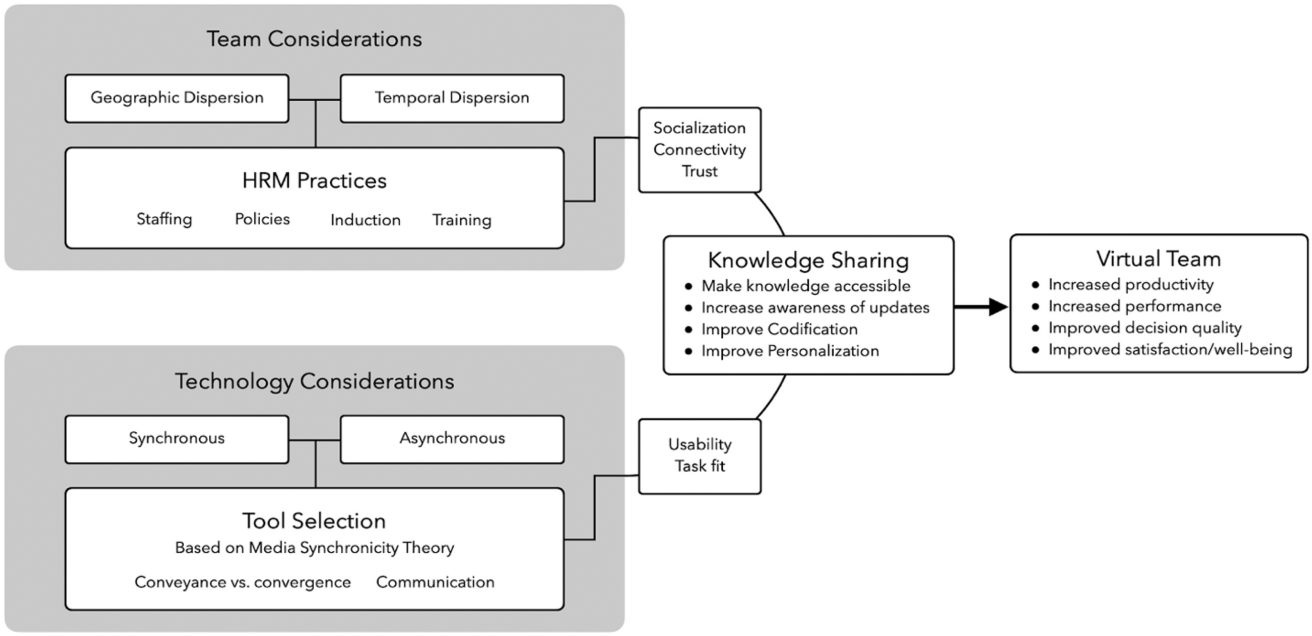
Number of Articles	Finding Categories	Knowledge Sharing	Outcomes
3	HRM practices	Make knowledge accessible	Increased productivity
8	Technology tool selection	Increase awareness of updates	Increased performance
10	HRM practices and Technology tool selection	Improve codification Improve personalization	Decision quality enhanced Improved satisfaction and well being

One of the first predominant themes included the importance of selecting the right tools based on the communication and collaboration needs of the team and helping make knowledge accessible to all across each VT. Evidence supports the notion that careful selection of technology tools for VTs can mitigate temporal and geographical dispersion. Whether the tools are predominantly synchronous or asynchronous factored into this tool selection process. Seven articles discuss chat/instant messaging and synchronous tool usage and their advantage for addressing geographic dispersion. Six authors discussed predominant themes relating to the use of asynchronous tools to mitigate temporal dispersion. A total of eight articles also featured the importance of training for technology tools as a primary theme, and six authors discussed the importance of training specific to knowledge sharing. Tying these themes together, it is apparent that training and tool selection are complementary in maximizing the value to the organization.

From the HRM perspective, seven papers discussed building trust among virtual teams, and another seven linked trust and comfort building to create less need for synchronous tools. Another important HRM theme was the emphasis on induction in the team-building process. The coding analysis reveals the overarching importance of socialization and connectivity resulting from the team building and induction phases.

In addition, several other common themes were highlighted that connect across the key categories, by emphasizing the following: (a) Making knowledge accessible to all and making others aware of updates; (b) Using discussion forums for idea sharing and team induction; (c) Utilizing a mix of tools in order to match the needs of the VT. Additionally, various specific effect dimensions related to productivity were revealed. Competitive advantage and increased performance were most common, with eight articles showcasing these two themes. Decision quality enhancement and process improvement were further dimensions of productivity noted across five articles, while four authors noted communication betterment and employee satisfaction/well-being. The primary themes and study outcome can be seen in the conceptual map (Figure 1), discussed further in the next section.

Figure 1: Conceptual Map of Critical Team and Technology Considerations Pertaining to HRM or Tech Tool Selection and the Key Findings with Implications



The findings resulting from the systematic review process and analysis of articles point to factors and considerations for enhancing VT productivity through knowledge sharing. By weaving together the findings, HRM practices and selection of technology tools were confirmed as critical in supporting an increase in productivity of VTs. Together these two factors enable linkage and connectivity of team members for success (Suh et al., 2011). More succinctly, Paloş (2012) mentions, "for virtual organizations, improved technology and the right human resources support translate into an increase in productivity" (p. 38). The discussion of the two major themes of technology tools and HRM practices and their associated sub-themes across several sectors and geographical areas based on this systematic review is included in subsequent sections.

4.1 HRM PRACTICES

HRM practices including specific policies, staffing considerations, training and induction of new teams and team members were found to be critical factors that can foster socialization, connectivity, and trust and enable knowledge sharing (Paloş, 2012; Pathak, 2015; Wang & Haggerty, 2011; Zhang et al., 2018). Because team members often do not know each other at the onset, there may be barriers to knowing who knows what, and "without effective knowledge management, virtual teams are likely to remain inefficient and lack cohesion" (Pathak 2015, p. 27). A common theme across more than 50% of the articles was that synchronous tools and communication were less necessary after more comfort and trust had been built among teams via HRM practices (Badrinarayanan & Arnett, 2008; Gaan, 2012; Gupta et al., 2009; Mesmer-Magnus et al., 2011; Montoya et al., 2009; Skopp et al., 2015). Alternatively, several papers mentioned the importance of overlapping shift times to ensure that there is at least some synchronous time when colleagues need to work through issues (Badrinarayanan & Arnett, 2008; Pathak, 2015; van der Meulen, 2019).

4.2 POLICIES

According to Gaan (2012), "organizational policies, and process orientation are the constituents of collaborative tools that influence the virtual team performance" (p. 5). Making knowledge available and known to all (building knowledge awareness) was an essential contributor to improved results (Badrinarayanan & Arnett, 2008; Guzmán et al., 2010; Oshri et al., 2008; Pathak, 2015; van der Meulen, 2019). Knowledge transfer and codification are further factors that facilitate success. This is accomplished by making sure knowledge is stored systematically to ensure it is useful to as many as possible (Gupta et al., 2009; Oshri et al., 2008). Organizations should develop mechanisms and/or policies that encourage or require employees to share their knowledge and provide updates when they do so. Furthermore, employees should be expected to assess the frequency and reliability of knowledge contributions (Badrinarayanan & Arnett, 2008; Guzmán et al., 2010; Pathak, 2015). Also, appraisals (performance reviews) were noted as a critical area for organizations. These should emphasize the importance of knowledge sharing by assessing whether employees share

what they know. Further, employees should be encouraged to inform colleagues when the knowledgebase is updated (Badrinarayanan & Arnett, 2008; Pathak, 2015; Wang & Haggerty, 2011). Thus, the literature recommends improving VT members' appraisals by assessing the frequency and completeness of knowledge sharing. Pathak (2015) connected incentives and the sharing of organizational knowledge amongst employees (p. 27). Finally, other key areas of focus include team forming (development), induction, and training of VTs.

4.3 TEAM FORMING AND INDUCTION

When building the team, significant factors include assessing competencies and team induction practices (Guzmán et al., 2010; Pathak, 2015; Wang & Haggerty, 2011). Additionally, teams have to contend with the usual stages of people coming together in team development. Tuckman's (1965) model of team development, with five critical stages, is known as (1) Forming; (2) Storming; (3) Norming; (4) Performing; and (5) Adjourning. These aspects of team development do not go away when forming VTs. Therefore, managers and leaders of VTs must be cognizant of these aspects of team development to ensure all the nuances associated with in-person team development are also taken into account during VT development.

Furthermore, it is vital in light of this knowledge of team development to understand what role competencies play during the stages of people coming together to form a team. Competencies have been defined for this research as skills, experiences, and knowledge (Grant & Baden-Fuller, 2018). Research notes that competency assessment in the initial team-building process plays a role in "forming" success. Wang and Haggerty (2011) showed "that individuals who have more experiences are more competent and therefore, may achieve better work outcomes in virtual settings" (p. 323). Wang (2011) further posited that hiring decisions could be made by managers based on assessing individual virtual competencies (IVCs) and experiences people have in their online life.

Induction, or orienting the teams to the organization and each other, was a common theme to help teams form close personal connections (Badrinarayanan & Arnett, 2008) and socialize (Oshri et al., 2008). Several authors also recommended some collocated or in-person time during induction when that possibility exists (Badrinarayanan & Arnett, 2008; DeLuca & Valacich, 2006; Pathak, 2015). Induction periods should include identifying knowledge gaps, making sure all team members understand what knowledge exists and where it is located (Pathak, 2015). This is a salient point related to "tacit knowledge," which is not codified or written down and is based on a person's beliefs, experiences, perspective, and value systems (Johnson, 2020, p. 64). This is one of the core strengths in VTs and is typically overlooked. Also, "for the collaboration to be successful, virtual teams must have specific trust-building activities, and all project aspects (purpose, objectives, risks involved) must be shared among team members." (Paloș, 2012, p. 41). Johnson (2020) observed that "one area of dilemma that is being faced at this juncture is when team orientations become very rigid or unyielding" (p.66). This observation indicates that knowledge sharing would not be supported in this environment, "hence an awareness needs surfaces and must be tended by managers" (Johnson, 2020, p.66). Finally, and more specifically, group norming should occur via a discussion about standards for availability of team members, acknowledgment of messages, and how quickly a response can be expected from each other (Montoya et al., 2009).

4.4 TRAINING

The importance of technology tool training for team members was a significant theme that emerged from the literature (Badrinarayanan & Arnett, 2008; Guzmán et al., 2010; Montoya et al., 2009). According to the research, organizations should assess what gaps may exist in their team's ability to codify and personalize knowledge sharing (Oshri et al., 2008; Paloș, 2012; Pathak, 2015; Wang & Haggerty, 2011; Zhang et al., 2018). HRM can ensure the training plan is oriented towards sharing knowledge. However, HRM must also create awareness about the importance of knowledge management for a virtual team's success and motivate workers to share their knowledge (Pathak, 2015). Oshri et al. (2008) further emphasize training for "common encoding of information in personalized and codified directories that, in turn, improved understanding and created a basis for efficient knowledge transfer between future remote counterparts" (p. 605). Finally, training should go further than just the technical "how-to" as team members need to know why each particular technology tool "is useful and when it is most appropriate to use relative to specific tasks and development projects" (Montoya et al., 2009, p. 151).

4.5 COLLOCATED VS. VIRTUAL TEAMS

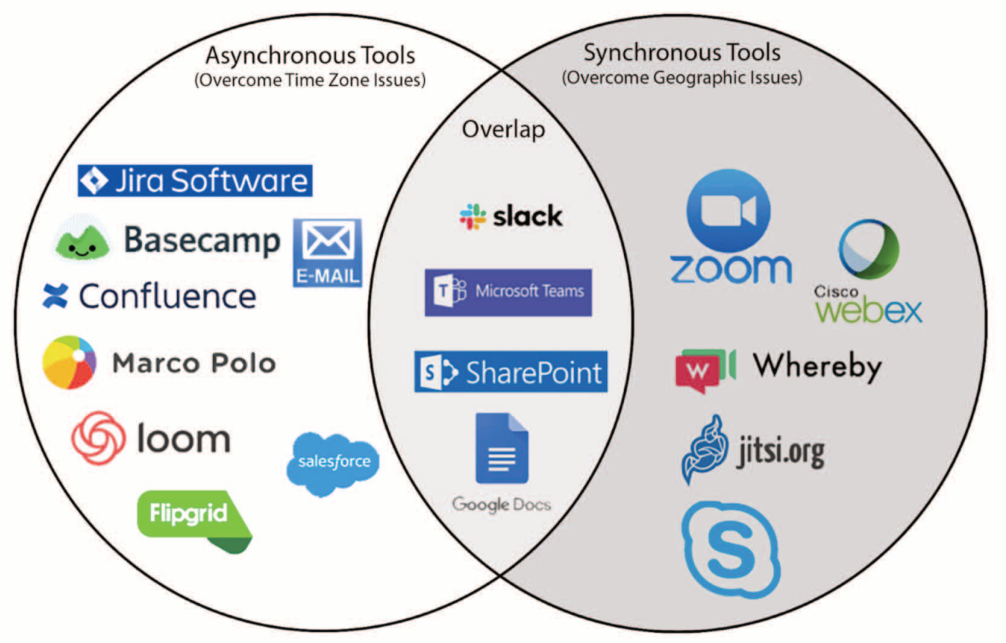
An unexpected theme drawn from the analysis relates to collocated teams compared to VTs and sheds light on ways they can improve upon knowledge sharing and performance. For example, Wang and Haggerty (2011) noted that both collocated and VTs use email and instant messaging to accomplish collaborative tasks (p. 300). On the scale of virtuality, even collocated teams who meet regularly in person are considered partially virtual since they all at least use email as a means of connection. It is important to note that unless a team operates entirely in-person and

without tools like email, they are all on the spectrum of virtual-based teams. Badrinarayanan and Arnett (2008) noted that in-person teams often lack recording or documentation, as many interactions can occur that do not result in codified, stored, shared knowledge. On the other hand, "in virtual interactions, there is a greater emphasis on verbalization (over demonstration), which facilitates the capturing, storing, and transmitting of implicit knowledge" (p. 245). This was further substantiated by Gupta et al. (2009), who noted that IBM corporate workers in VTs located in the US and India share knowledge more through documentation and formal codification processes to resolve issues, while collocated teams relied on informal in-person interactions and tended not to document their decision-making (p. 157). Also, Mesmer-Magnus et al. (2011) conducted a meta-analysis of 90 studies on VTs worldwide. They found that "the type of information that tends to be shared within in-person teams as compared with VTs is exactly opposite that which is likely to promote the highest levels of performance in these teams" (p. 221). By the very nature of VTs relying upon various technology tools to communicate and moderate synchronicity, VTs "engage in more information sharing than in-person teams" (Mesmer-Magnus et al., 2011, p. 220). Kotlarsky et al. (2007) conjectured that there are specific strategies for use before, during, and after in-person meetings to strengthen or renew social ties among team members. For example, teams can use email to resolve understandings and intranet to post internal documents before meetings, and use chat and application sharing to address short questions after a meeting (p. 21).

4.6 TECHNOLOGY TOOL FACTORS

There are two primary categories of technology tool usages that are utilized by VTs: asynchronous and synchronous. A tool itself may be used either synchronously, asynchronously or a mix of both, depending on the work task and situation. Factors related to technology tools were featured across the threads of the research synthesis. Many articles revealed themes relating to technology tools and their role in knowledge sharing and VT productivity. The predominant sub-theme relating to these tools is that of synchronicity. From a theoretical perspective, both MST and TTFT were cited to influence decision-making regarding the tools with an emphasis on choosing them based on the team's communication needs to have the best fit for the tasks at hand. See examples of these tools in Figure 2. Whether the goal of the communication was conveyance or convergence, the tool's choice was found to influence the success of VTs. Specifically, multiple articles found that technology tools can mitigate the adverse effects of teams' geographical dispersion by enabling collaboration and information exchange that fosters efficiency (Bhardan et al., 2013; van der Meulen et al., 2019). Further, in a study on business consulting teams in Korea, Suh et al. (2011) posited that technology tools for communication could help build social networks with desirable characteristics, and "using these technologies to enhance intra-group tie strength can increase group solidarity, cooperation, and information sharing" (p. 353). This was further supported in a study across virtual software development teams in India, Germany, Switzerland, and the USA, in which Kotlarsky et al. (2007) recommended the use of technology tools because they supported the strengthening of social ties.

Figure 2. Common Tools Used for Asynchronous Communications are Shown on the left, with Synchronous Tools on the Right, and Tools with Some Overlap in the Middle



4.7 ASYNCHRONOUS TECHNOLOGY TOOLS

Asynchronous tools naturally facilitate communication for teams that have a great deal of temporal dispersion. Email, discussion forums, knowledge management databases, and project management systems provide teams with the ability to convey knowledge and information (DeLuca & Valacich, 2006). Such tools also give people more time to process and respond. This can lower barriers due to cultural or language differences for global teams (Gaan, 2012). Asynchronous use of technology tools can also help reduce stressful interruptions that can cause delays and loss of productivity and quality (Guzmán et al., 2010, p. 430). However, van der Meulen et al. (2019) pointed out that the use of asynchronous tools among teams with a great deal of temporal dispersion can harm knowledge awareness, and they recommended the synchronization of working times when possible. Furthermore, researchers also note that decision-making and convergence are often better suited to synchronous technology tools (DeLuca & Valacich, 2006; Paloş, 2012; van der Meulen et al., 2019).

4.8 SYNCHRONOUS TECHNOLOGY TOOLS

Synchronous tools have improved tremendously since the early 2000s. Examples include Slack, Microsoft Teams, and other similar instant message applications. As these tools become commonplace, they are increasing communication and knowledge sharing. Though such tools are often thought of as synchronous, they are frequently used asynchronously. For example, one might receive an instant message and respond hours later if one is off work, at lunch, or in a meeting. Videoconferencing has become more usable and affordable, and the quality has increased over the past decade (Shah-Nelson, 2013). Services such as Adobe Connect, Google Hangouts, and Zoom have greatly improved the ease-of-use and usability across different bandwidths. The improvement of these communication methods has reduced costs due to companies no longer needing extensive proprietary and costly video conferencing systems and a reduced need for travel (DeLuca et al., 2006; Montoya et al., 2009). These mechanisms replicate the in-person communication found in collocated teams as closely as possible (Montoya et al., 2009, p. 152). Although these contrivances do not greatly assist with issues of temporal dispersion (Gupta et al., 2009), the ability to easily record the conversation does have the effect of providing asynchronous access to the knowledge and communications they contain, which can be to the benefit of the VTs who use them. When in use by VTs the tools can facilitate decision-making, instant feedback, and convergence communications across teams that can significantly enhance knowledge sharing (Bhardan et al., 2013; DeLuca & Valacich, 2006; Montoya et al., 2009).

4.9 TECHNOLOGY FIT

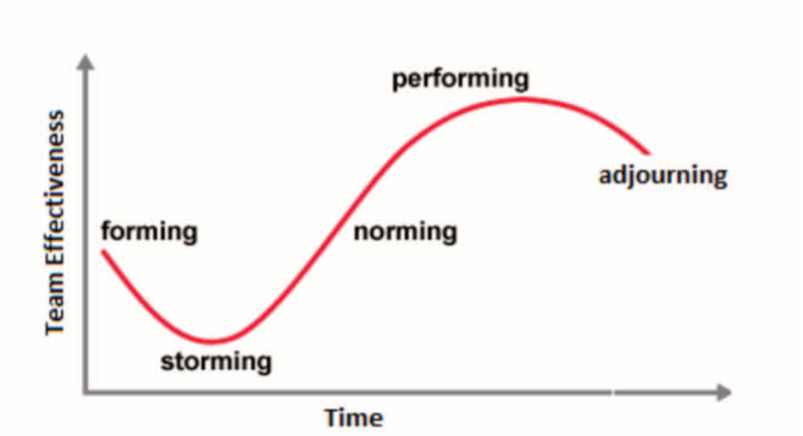
The fit of the technology to the specific task was a sub-theme in the literature related to successful VTs performance. Zhang et al. (2018) found via a large-scale survey of inter-organizational teams in the USA and China that "tool usability, task fit, and team connectivity contribute to virtual collaboration effectiveness, which affects project management success and team appreciation" (p. 1096). This continues to support Montoya et al. (2009), who noted in a study of virtual new product development teams across 18 countries that "team members need to know why an ICT (information communications technology) is useful and when it is most appropriate to use relative to specific tasks" (p. 151). Zhang et al. (2018) further noted that "tool usefulness, team connectivity, and task fit had stronger impacts on virtual collaboration effectiveness than tool ease-of-use" (p. 1102), which has significant implications when VTs in the future need to select tools for sharing knowledge. They need not focus on, or factor in, ease-of-use as a primary outcome. This is corroborated by Gaan's (2012) study of 25 virtual software development teams in India, which concluded that there is a critical need to examine the fit of the technology tools and select them to fit the task. One of the implications of this finding is that companies need to carefully coordinate information technology, HRM, leadership, and management to ensure alignment between the organizational goals, tasks, communication needs, and technologies.

5 DISCUSSION

The findings based on the systematic review and analysis of the data leads to several important discussion points. First, these findings support technology tool choice and decision-making based on a combination of TTFT and MST theories, which underpinned the study. Such decisions can optimally be made based on a VT's level of temporal and geographic dispersion (to determine the needed synchronicity level of tools) and the tools' fit to complete the necessary tasks. These decisions should also keep knowledge sharing capability at the forefront to help ensure that they are used to maximize capturing, retrieving, and sharing of knowledge and codifying tacit knowledge to make it explicit and accessible. The findings also point to several important HRM considerations for VTs. Tuckman's model (Figure 3) provides a basis for discussing team development stages of forming, storming,

norming, performing, and adjourning. The findings support the need to consider the uniqueness of VTs in the context of team development to enhance team productivity. Time and team effectiveness (performance) are closely connected to teams' key performance indicators (KPIs). This became more obvious with the onset of the COVID-19 pandemic with the rapid formation of many VTs. Many of the teams were forced into VTs that were forming and storming at the same time.

Figure 3: Tuckman's Five Stages of Team Development



Note. Derived from *Five Stages of Team Development,* by: John/Lynn Bruton and Lumen Learning (n.d.). Licensed under CC-BY 4.0.

Research shows that forming and storming are times of conflict in team development, with the storming phase being the time of significant conflict (Curlee & Gordon, 2004). The current research findings indicate that HRM practices play a pivotal role in the support rendered during team formation. By having well-defined project roles, job descriptions, appraisal criteria, and team forming practices, HR managers can facilitate high functioning team forming. Trust is a critical element of team formation and is more crucial for VTs due to the nature of these teams in terms of temporal and geographical dispersion. Consequently, this puts more onus on leaders and managers of VTs to consider how to build trust and socialize teams during team forming and storming phases of team development via well-planned induction practices. To facilitate a smooth transition past the storming phase of team development, the team leader should consider the research finding of ensuring the HRM practices, policies, and technology tools are all in place to support the VTs. The research also indicated that understanding the functionality of technology tools for communicating and sharing knowledge is paramount to supporting VTs during the forming and storming phases of team development. This will play a pivotal role in giving assurances to VTs that knowledge is not being withheld and that transparency is valued by management. Hence, collaboration between HRM and leaders/managers of VTs should be prioritized to ensure productivity success is addressed early in team formation (development) as part of the VTs goals and objectives.

Furthermore, the research indicated that it is imperative to ensure that productivity is enhanced during the norming and performing phases of VTs team development. Tuckman's model indicates that during the norming phase of development, teams are beginning to be effective. Consequently, productivity becomes more fully realized at this phase. This knowledge helps leaders of VTs support their teams by ensuring the correct technology tools are being utilized, by evaluating whether synchronous or asynchronous tools are the best fit for their teams in decision-making, productivity, and knowledge sharing. At this stage, a re-assessment of the tools and practices is recommended to see if adjustments are needed. As a result of this assessment, the performing phase of team development becomes more fully supported. Performance is at its highest peak in VTs if both HRM practices and technology tools fit for purpose are in place to support VTs. The ability of VTs to communicate effectively thereby becomes the cohesive network of high performing VTs that in turn support high productivity. Consequently, knowledge sharing is at its optimum and should be capitalized by both HRM and leaders/managers of VTs. This is the area of peak synergy when MST and TTFT theories intersect in support of teams and, more specifically, VTs during the project's performing phase.

The adjourning phase of team development is a critical juncture. This is the phase when tacit knowledge is often lost, and productivity starts to fall off due to teams scattering and moving on to other projects. The research indicated that VTs typically are successful if they are given the correct technology tools to support their projects. However, in many instances, this area is often overlooked by leaders/managers of VTs. The current research showed that technology tools, when utilized appropriately, can become the mechanisms to capture and retain tacit knowledge.

When codified, the tacit knowledge will, in this instance, become part of the enduring knowledge formulated by VTs for future use or can become the competitive advantage when working across VTs outside of organizations or during mergers and acquisitions. Likewise, HR managers can further support the codification of knowledge through policies that support appraisal of employee knowledge sharing and provide incentives for doing so through all team development stages.

5.1 RECOMMENDATIONS FOR MANAGERS

Several managerial implications and recommendations came out of the findings. Managers will want to help VTs share and transfer knowledge effectively and efficiently by being strategic with technology tools selection and HRM practices. Managerial support in the form of resources, availability of task-appropriate tools, and HRM practices that foster trust and socialization must be emphasized due to the rapid formation of VTs due to the COVID-19 pandemic. For knowledge to be effectively shared, tacit knowledge must be captured and codified to be accessible across boundaries. This is in-line with the observations from (Johnson, 2020) that companies must codify and convert tacit knowledge to explicit knowledge.

Six recommendations emerged as part of this systematic review. Both organizations and managers must address these recommendations to support VTs. However, this has taken on greater meaning for VTs that have been forced into a rapid formation due to the COVID 19 pandemic:

1. Document and create a plan for technology tool usage based on VTs' geographical locations and temporal dispersion. The more temporally dispersed the team, the more need for asynchronous tool usage, including email, project management systems, discussion forums, and instant messaging. The plan should be executed immediately during team development and should be part of the HRM induction onboarding process and encouraged at all weekly departmental or team meetings.
2. Team leaders and managers must integrate technology synchronously (video conferencing whenever possible, or instant messaging) for decision-making, resolving understanding issues, or convergence communication. Share video to help build socialization and trust. Take time to discuss non-work-related topics to forge personal connections. Once trust is established as a norm, teams can move toward more asynchronous technologies.
3. Provide training for technology tool usage that covers the how-to, the why, and especially, the guidelines for use that help the team be informed and aware of new knowledge.
4. HRM: Include knowledge sharing practices in job responsibilities; assess and screen candidates based on past VT work, technology tool usage, and knowledge sharing practices. Once hired, provide relevant and specific training based on the assessment outcomes.
5. HRM: Orient new VTs and VT team members through a period of induction by utilizing Tuckman's team development model that includes getting to know each other, forming deep connections, and discussing standards relating to availability and responsiveness in communications.
6. HRM: Adjourning: Appraise VT members on their frequency and completeness of knowledge sharing and consider incentives such as gift cards or bonuses as potentially useful for the team to ensure that they share their knowledge.

6 CONCLUSION

Based on this systematic review and synthesis of twenty-one scholarly journal articles' findings, two primary factors emerged from the literature regarding virtual teams enhancing productivity via knowledge sharing. These categories are technology selection and HRM factors. Together, these can help mitigate the issues of geographical and temporal dispersion of virtual teams. While each separate article had its context and findings, this systematic review contributes to the field by synthesizing findings across various contexts and sectors to provide a more generalizable set of recommendations. The research leads to several implications and recommendations for practitioners, including the careful consideration of technology tool affordances to match the intended communication goals while focusing on usability and task fit.

Moreover, the implementation of crucial HRM practices and policies regarding team induction and training that facilitate socialization, team building, and trust are recommended. New knowledge was acquired of particular interest in light of the global pandemic of COVID-19 with VTs springing up across the globe on a grander scale. The current research supports HRM practices and technology tools looking through new theoretical lenses not previously utilized. The theoretical implications of using MST and TTFT provide a robust basis for an in-depth understanding of what supports productivity in VTs. Both MST and TTFT not only support the hypotheses that both productivity and synchronicity are enhanced, but the theories support a deeper understanding of the effects of collaboration within VTs. The greater the collaboration, the greater the productivity of VTs. This understanding

has substantial implications for leaders/managers and organizations when supporting VTs. The research further explores the conceptual framework of using Tuckman's team development model to expound on the knowledge garnered from the study of VTs across different sectors and globally. Tuckman's model reinforces the idea that VTs need to have the strong support of HRM and the availability of technology-focused tools fit for purpose at the earliest stages of team development during forming and storming stages. The support does not go away until the adjourning aspect of team development is realized and thus creates a considerable onus on leaders/managers to support VTs through the entire lifecycle of team development in support of productivity.

6.1 LIMITATIONS AND FUTURE RESEARCH

This study has several limitations. While all articles included were deemed fit, several were conceptual papers and not empirical. Most studies were cross-sectional, or case studies on a multi-country or global perspective, but the lack of longitudinal studies causality were not established. A sizable number of the teams studied were either technology, software, or NPD oriented. Resultingly, some bias toward those industries and sectors may be present in the findings.

Future research would benefit from a longitudinal study to analyze particular sectors or industries. There were several articles specific to NPD teams, software development teams, and other high technology teams. Hence, there may be enough studies available for a researcher to do a systematic review of only NPD teams to best report on a particular business sector. Future research into more specific effects relating to creativity or innovation by VTs would be useful for both scholars and practitioners. The proliferation of instant messaging replacing email among workgroups in the past five to ten years lends weight to future research for empirical evidence of the differences in outcomes between using IM versus email. Finally, with such a high percentage of the world now working remotely during the COVID-19 pandemic, we are enthusiastic that more empirical data will emerge regarding VTs knowledge sharing, productivity, and creativity related to technology, HRM, and all aspects of knowledge management.

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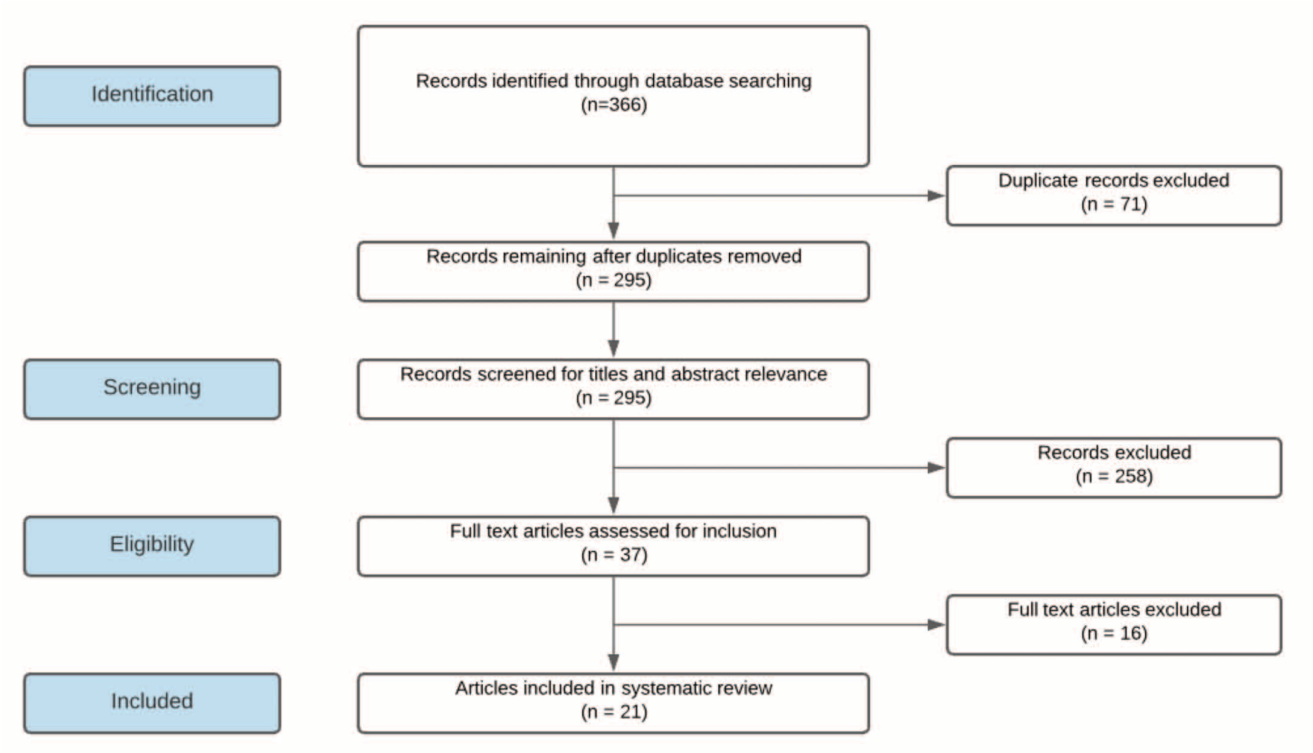
Appendix 1

Table 1a. Search Strings and results: UMGC OneSearch includes (but is not limited only to) the following databases: Business Insights: Essentials, Business Source Complete, Computer Science OneFile, Computers & Applied Sciences Complete, Education Research Complete, Emerald Insight, JSTOR

Database	String	Result #
UMGC OneSearch	("virtual team*" OR "remote team*" OR "distributed team*" OR "dispersed team*") AND ("knowledge management" OR "knowledge sharing" or "knowledge transfer") AND efficien* AND "synchronicity theory" OneSearch 68 (all text)	38
UMGC OneSearch	("virtual team*" OR "remote team*" OR "distributed team*" OR "dispersed team*") AND ("knowledge management" OR "knowledge sharing" or "knowledge transfer") AND efficien* (abstract, OneSearch)	3
UMGC OneSearch	("virtual team*" OR "remote team*" OR "distributed team*" OR "dispersed team*") AND ("knowledge management" OR "knowledge sharing" or "knowledge transfer") (OneSearch - titles)	15
UMGC OneSearch	("virtual team*" OR "remote team*" OR "distributed team*" OR "dispersed team*") AND ("knowledge management" OR "efficient knowledge management" OR "efficient knowledge sharing" OR "knowledge transfer") (OneSearch abstract)	42
ABI/Inform	("instant messag*" OR slack OR "google hangout*" OR "microsoft teams" OR "online chat*") AND ("video conferenc*" OR videoconferenc* OR teleconferenc* OR "screen shar*") AND (efficien* OR effective* OR success* OR productiv*) AND "knowledge management" AND ("virtual team*" OR "remote team*" OR "distributed team*" OR "dispersed team*") peer reviewed √ 2006-2019 full text is not checked in "anywhere"	78
UMGC OneSearch	("instant messag*" OR slack OR "google hangout*" OR "microsoft teams" OR "online chat*") AND ("video conferenc*" OR videoconferenc* OR teleconferenc* OR "screen shar*") AND (efficien* OR effective* OR success* OR productiv*) AND "knowledge management" AND ("virtual team*" OR "remote team*" OR "distributed team*" OR "dispersed team*")	190
TOTAL		366
	-DUPLICATES	71
TOTAL		**295**

Appendix 2

Figure 2a. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) shows the number of articles identified, screened and included/excluded



Appendix 3

Table 3a. Data extraction table of included articles displaying authors, sectors, study design and sample size, countries, and primary findings area

Author(s) & Year	Sector/	Design & Sample Size	Countries	Primary Findings Area
Badrinarayanan & Arnett, 2008	virtual new product development (NPD)	literature synthesis/ conceptual paper	?	HRM
Bardhan et al., 2013	multiple US industries, large cross-section of US firms, projects	mixed methods, 636	USA	Tech Tools
Bosch-Sijtsema et al., 2009	distributed teams, global tech companies	conceptual paper	?	HRM/Tech Tools
Capece & Costa, 2009	virtual teams, Italy, website development	conceptual + case study, 4 teams of 6 members	Italy	Tech Tools
Deluca & Valacich, 2006	virtual teams (newly formed) Eight business process improvement teams	action research, 76	USA	Tech Tools
Deluca et al., 2006	virtual teams, educational services organization	action research	USA	Tech Tools
Gaan, 2012	IT virtual teams; software professionals	qualitative grounded theory; 25 teams	India	HRM/Tech Tools
Gupta et al., 2009	virtual vs. co-located teams; IBM corporation	quasi-experiment	USA/India	HRM/Tech Tools
Guzman et al., 2010	global software teams	literature synthesis/ conceptual paper, 462	30 different countries	HRM/Tech Tools
Kotlarsky et al., 2007	virtual software dev teams	case study,	India, Germany, Switzerland, USA	HRM/Tech Tools
Mesmer-Magnus et al., 2011	virtual teams	meta analysis, 90 studies, 19,702 individuals	Global	Tech Tools
Montoya et al., 2009	new product dev (NPD) virtual teams	virtual NPD team members, 184	18 countries	HRM/Tech Tools
Oshri et al., 2008	global distributed teams, India, USA, Swiss, banking	case study, 14	India, USA, Switzerland	HRM/Tech Tools
Palos, 2012	virtual teams	literature synthesis/ conceptual paper	N/A	Tech Tools
Pathak, 2015	gray lit. article (3 pages, no references)	n/a	N/A	HRM
Senquiz-Diaz & Ortiz-Soto, 2019	virtual teams	literature synthesis/ conceptual paper	N/A	HRM/Tech Tools
Skopp et al., 2015	n/a	literature synthesis/ conceptual paper	N/A	Tech Tools
Suh et al., 2011	business consulting teams, Korea	conceptual paper	Korea	HRM/Tech Tools
van der Meulen et al., 2019	knowledge workers, Europe	mixed methods, 90	Europe	Tech Tools
Wang & Haggerty, 2011	virtualized workplace, students and Business school alumni	self-report online survey, 199	North America	HRM
Zhang et al., 2018	inter-org collab. projects; China/USA	literature synthesis/ conceptual paper, 462	China, USA	Tech Tools