A conceptual framework of virtual team effectiveness from the Socio-Technical perspective

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ABSTRACT

In the era of globalization and technologization, virtual teamwork has become a routine part of professional activity in the software industry and other industries. Understanding virtual team effectiveness helps the management to improve the overall effectiveness of organizations. In this paper, we conduct a literature review of team research to set up a conceptual framework of virtual team effectiveness based on the socio-technical perspective and Inputs-Mediators-Outputs-Inputs model. Our framework includes some salient inputs, mediators and outputs of virtual team life-cycle; specifically, technology readiness and intention to explore are two technical antecedents; team learning and transactive memory system are two social antecedents; and team performance is a socio-technical output representing virtual team effectiveness. After that, a 27-item measuring instrument of aforesaid concepts is proposed after a qualitative survey of 19 virtual team leaders and a quantitative survey of 151 virtual team members from 19 companies locating in Vietnam. The results are references for those interested in improving virtual team effectiveness.

1. Introduction

Thanks to the rapid development and extensive application of information and communication technology, opportunities for collaboration that are offered to the virtual team when it works across time, space and organizational boundaries. It has become an important component of organizations as it enables to cope with the market change and requirement (Bhat, Pande, & Ahuja, 2017). Researchers have offered many definitions of virtual teams and to some extent the definition of a virtual team can be viewed as completed, however, there are very few definitions of an effective virtual team. Referring to the review of R. Friedrich (2017), in this paper, an effective virtual team is: (1) geographically dispersed (over different time zones); (2) driven by a common purpose; (3) enabled by communication technologies; (4) involved in cross-boundary collaboration; (5) work with the same communication processes. The challenge

for research is determining how to integrate the contributions of virtual team members to bring added value to its effectiveness. With the aim of supplying more reference to virtual team research, this paper consists of 2 steps: (1) literature review; (2) exploratory research (including a qualitative survey and a quantitative survey).

Firstly, because the virtual team is a special team, team research is reviewed to build up a conceptual framework of virtual team effectiveness. In the team research area, hundreds of primary studies have been conducted, several meta-analyses have been performed, and numerous reviews of the literature have been published. They show that there have been some remarkable types of virtual team effectiveness models. Among them, the IMOI model suggested by Ilgen, Hollenbeck, Johnson, and Jundt (2005) is considered as a considerable development of the IPO model that has been applied widely in virtual team research (Dulebohn & Hoch, 2017; Mathieu, Maynard, Rapp, & Gilson, 2008; Rico et al., 2010). The IMOI model employs "M" to reflect the wide range of variables that are important mediational influences on explanatory power for explaining variability in virtual team effectiveness. It also adds the extra "I" at the end of the model to represent the inherent cyclical nature of virtual team functioning by highlighting feedback processes, so that some virtual team's outputs at a given moment represent new inputs for subsequent activity. In this paper, the IMOI model helps us propose an initial framework describing virtual team life-cycle with 02 main parts: (1) antecedents of virtual team effectiveness, including: (i) inputs, and (ii) mediators; (2) virtual team effectiveness, meaning outputs. Secondly, the virtual team includes intercultural-dispersed members and communicates through technology tools instead of face-to-face meetings. It uses technology tools to allow dispersed members to combine their knowledge and skills without the expenses of travel. That's why many multinational companies in both the software industry and other industries utilize virtual team to achieve operational efficiency and improve strategic performance despite it also brings risks (Alsharo, Gregg, & Ramirez, 2017; Dulebohn & Hoch, 2017; R. Friedrich, 2017; Osman, 2017). As a virtual team that is social-complex depends on technology, the socio-technical perspective is suitable to study its functioning. In this paper, the socio-technical perspective helps us consider some salient antecedents of virtual team effectiveness as: (1) social antecedents; (2) technical antecedents.

On the method aspect, rather than attempting to provide a comprehensive review of work that has been done in the past, we opt to discuss the evolution and the applications of the IMOI model and socio-technical perspective in studying virtual team effectiveness. Using this foundation, we feature previously selected works that have focused on different representative aspects of the virtual team or provide a vehicle for highlighting some novel findings or approaches. After the literature review, a conceptual framework and inherited scales of identified concepts are specified. Then we conduct exploratory research with a qualitative survey and a quantitative survey to modify inherited scales and propose the measuring instrument.

2. Literature review

2.1. The IMOI model and its application in virtual team research

According to the reviews of Mathieu et al. (2008), and Rico et al. (2010), the IMOI model of Ilgen et al. (2005) is the most prominent development of the IPO model which considers team as a multi-level system that contains emergent states resulting from the regular and repeated interaction of their members. Relying on the IMOI model, team research has largely investigated the influences of work team characteristics and team structures on team effectiveness. The IMOI model helps to solve two considerable criticisms of the IPO model: (1) inability to incorporate the temporal and recursive aspects imposed on teams by development and feedback so that it can overlook the adaptive and incremental learning processes that necessarily influence effectiveness; (2) unitary, simplified and opaque treatment of team processes. It is believed that the IMOI model better reflects the functioning of teams as complex adaptive systems operating in broader contexts.

In the IMOI model, (1) inputs describe antecedents that enable and constrain members' interactions. Inputs include the context of the organization, task design/team context, individual-level inputs/team composition inputs. The combination of these various factors influences team processes, which describe members' interactions directed towards task accomplishment. (2) Mediators are also important antecedents because they describe how inputs are transformed into outputs. Mediators include team processes, emergent states, and blended mediators. (3) Outputs are results and by-products of team activity that are valued by one or more stakeholders. Outputs include team performance and members' effect and viability (Mathieu et al., 2008; Rico et al., 2010). Some remarkable inputs, mediators and outputs of team effectiveness mentioned in recent studies are shown in Table 1.

Table 1

Some remarkable inputs, mediators and outputs of team effectiveness

Kinds of factors	Factors	Some works that mentioned
Inputs		
a. The context of the organization	a1. Human resource systems	Birdi et al. (2008), van Roosmalen (2012), Sharif and Nahas (2013)
	a2. Openness climate	Beltrán-Martín, Roca-Puig, Escrig-Tena, and Bou-Llusar (2008), Parker (2011), Xue, Bradley, and Liang (2011)
	a3. Multiteam systems coordination	Mathieu, Maynard, Taylor, Gilson, and Ruddy (2007), Salas, Goodwin, and Burke (2009)
	a4. Top management team-environment interface	Cannella, Park, and Lee (2008), Salas et al. (2009), Guest (2011)

Kinds of factors	Factors	Some works that mentioned
Inputs		
	a5. Cultural influence on teams	Sharif and Nahas (2013), Mueller (2015), Cheng et al. (2016)
b. Task design and team context	b1. Interdependence	Rico, Alcover, Sánchez-Manzanares, and Gil (2009), Lee, Lin, Huang, Huang, and Teng (2015)
	b2. Technology/ Virtuality	Salas et al. (2009), Breuer, Hüffmeier, and Hertel (2016), Schaubroeck and Yu (2017)
	b3. Team training/ Teambuilding	Salas et al. (2008), Hughes et al. (2016)
	b4. Team leadership/ Coaching	Zaccaro, Heinen, and Shuffler (2009), Grille, Schulte, and Kauffeld (2015), Moe, Cruzes, Dybå, and Engebretsen (2015)
	b5. Team structure	Kavadias and Sommer (2009), Hoch and Kozlowski (2014), Glukhov, Ilin, and Levina (2015), Erickson, Noonan, Carter, McGurn, and Purifoy (2015)
c. Individual level inputs/ Team composition inputs	c1. Personality	Jacques, Garger, Brown, and Deale (2009), Prewett, Walvoord, Stilson, Rossi, and Brannick (2009), Booth (2011), Cogliser, Gardner, Gavin, and Broberg (2012), Luse, McElroy, Townsend, and Demarie (2013)
	c2. Competencies	Mohammed, Ferzandi, and Hamilton (2010), Ziek and Smulowitz (2014)
	c3. Demographic	Algesheimer, Dholakia, and Gurău (2011), Booth (2011), S. T. Bell, Villado, Lukasik, Belau, and Briggs (2011)
	c4. Functional diversity	Cannella et al. (2008), Peters and Karren (2009)
	c5. Attitudes/ values	De Hoogh and Den Hartog (2008), Mohammed et al. (2010), Biscaia, Correia, Rosado, Ross, and Maroco (2013)
Mediators		
d. Team processes	d1. Transition processes	Mathieu and Rapp (2009), T. L. Friedrich, Griffith, and Mumford (2016)
	d2. Action processes	LePine, Piccolo, Jackson, Mathieu, and Saul (2008), Rothrock, Cohen, Yin, Thiruvengada, and Nahum-Shani (2009), Berry (2011), Salas, Shuffler, Thayer, Bedwell, and Lazzara (2015), Ellwart, Happ, Gurtner, and Rack (2015)

Kinds of factors	Factors	Some works that mentioned
Inputs		
	d3. Interpersonal processes	Gil, Rico, and Sánchez-Manzanares (2008), Liu, Magjuka, and Lee (2008), Saafein and Shaykhian (2014), Majchrzak, Rice, King, Malhotra, and Ba (2014), Hu and Liden (2015)
	d4. Other processes	LePine et al. (2008), To, Tse, and Ashkanasy (2015)
e. Emergent states	e1. Team confidence	C.-P. Lin, Baruch, and Shih (2012), Zimmermann and Ravishankar (2014), Ayoko and Chua (2014)
	e2. Team empowerment	Hempel, Zhang, and Han (2012), Erkutlu and Chafra (2012), Maynard, Mathieu, Gilson, O'Boyle, Jr., and Cigularov (2013), Kukenberger, Mathieu, and Ruddy (2015)
	e3. Climate	Chu-Weininger et al. (2010), Zohar, Huang, Lee, and Robertson (2014)
	e4. Cohesion	Callow, Smith, Hardy, Arthur, and Hardy (2009), Tekleab, Quigley, and Tesluk (2009), Mach, Dolan, and Tzafrir (2010)
	e5. Trust	Mach et al. (2010), Collins and Chou (2013)
	e6. Collective cognition	DeChurch and Mesmer-Magnus (2010), van den Bossche, Gijselaers, Segers, Woltjer, and Kirschner (2011)
f. Blended mediators	f1. Team learning	Kozlowski and Bell (2008), van den Bossche et al. (2011), Carmeli, Tishler, and Edmondson (2012), Kukenberger et al. (2015), Tekleab, Karaca, Quigley, and Tsang (2016), Kassim and Nor (2017)
	f2. Behavioral integration	Carmeli and Halevi (2009), On, Liang, Priem, and Shaffer (2013), Tekleab et al. (2016)
	f3. Transactive memory	Choi, Lee, and Yoo (2010), Shatdal and Vohra (2011), Ren and Argote (2011), Hsu, Shih, Chiang, and Liu (2012), Zheng (2012), Argote and Ren (2012), Kotlarsky, van den Hooff, and Houtman (2015), Liao, O'Brien, Jimmieson, and Restubog (2015), Chung, Lee, and Han (2015)
Outputs		
g. Team performance	g1. Organizational-level performance	Carmeli et al. (2012), J. Y. Jiang and Liu (2015), X.-a. Zhang, Li, Ullrich, and van Dick (2015)
	g2. Team performance	Kukenberger et al. (2015), Owens and Hekman

Kinds of factors	Factors	Some works that mentioned
Inputs		
	behaviors and outcomes	(2016), Bowers, Oser, Salas, and Cannon-Bowers (2018)
	g3. Role-based performance	Leroy, Anseel, Gardner, and Sels (2015), Fransen et al. (2016), Hauer et al. (2016)
	g4. Performance composites	C.-P. Lin et al. (2012), Ellwart et al. (2015)
h. Members' effect and viability	h1. Members' affective reactions	Li, Li, and Wang (2009), Boies and Howell (2009), Rozell and Scroggins (2010), Cicei (2012), Rincon et al. (2012), Zeitun, Abdulqader, and Alshare (2013)
	h2. Team viability	Rousseau and Aubé (2010), S. T. Bell and Marentette (2011), Costa, Passos, and Barata (2015), Peñarroja, Orengo, and Zornoza (2017)

Source: The researcher's data analysis

Virtual team has become interesting while having the great number of research in recent years (e.g., Bergiel, Bergiel, & Balsmeier, 2008; Curşeu, Schalk, & Wessel, 2008; Dulebohn & Hoch, 2017; Ebrahim, Ahmed, & Taha, 2009; R. Friedrich, 2017; Gilson, Maynard, Young, Vartiainen, & Hakonen, 2015; Hoch & Dulebohn, 2017; Marlow, Lacerenza, & Salas, 2017; Mihhailova, 2007). Recently, Dulebohn and Hoch (2017) proposed a conceptual framework of virtual team effectiveness which proved that the IMOI model is also an useful framework to study virtual teams. At first, in that framework, there are three input categories which represent key deterministic criteria for virtual teams: (1) organizational-level factors (B. S. Bell & Kozlowski, 2002; Hoch & Kozlowski, 2014); (2) team leadership factors (Kozlowski & Bell, 2003; Zaccaro, Rittman, & Marks, 2001); (3) team composition (Driskell & Salas, 2013; Ferreira, da Rocha, & da Silva, 2014; Hoch & Dulebohn, 2013). Next, team process factors and emergent states are mediators of the inputs and outcomes relationship. Team processes refer to team members' interdependent acts of transforming inputs into outcomes. In contrast, emergent states represent tap qualities of a team, these types of construct characterize properties of the team that are typically dynamic in nature and vary as a function of team context, inputs, processes, and outcomes (Marks, Mathieu, & Zaccaro, 2001). Next, Dulebohn and Hoch (2017) recognize the differences and the position of emergent states and processes including cognitive processes (such as team cognition and cognitive climate), motivational processes (such as teamwork engagement), effective processes (such as team cohesion) and behavioral processes (such as shared leadership, communication, and technology usage) (Kozlowski & Bell, 2003; Marks et al., 2001; Mathieu et al., 2008; Zaccaro et al., 2001). Meanwhile, moderators include factors that may moderate the input and team process pathway as well as the team process and outcomes pathway by affecting the direction and/or the strength of the relationships in the model (B. S. Bell & Kozlowski, 2002; Bowers, Pharmer, & Salas, 2000; Hambrick, Humphrey,

& Gupta, 2015). Finally, outputs represent the effect of the processes transforming team inputs into outcomes that are valued by the organization. Virtual teams generally exist to achieve certain goals, deliverables, performance outcomes, etc. Dulebohn and Hoch (2017) have designated two levels of outcomes: (1) team level outcomes that represent the degree to which the team achieves performance goals and objectives, represented by indicators such as team performance and effectiveness; (2) individual team member outcomes that reflect member performance, effectiveness, and attitudes such as satisfaction and commitment.

2.2. The socio-technical perspective in virtual team research

The Socio-Technical System (STS) theory is the most relevant representative of socio-technical perspective in research. This theory initially mentioned that both the interaction of technology, people and work systems lead to high job satisfaction. If a technical system is created at the expense of a social system, the results obtained will be optimal (Mumford & Beekman, 1994). Based on the STS theory, socio-technical research is premised on the interdependent and inextricably linked relationships among the features of any technological object or system and the social norms, rules of use and participation by a broad range of human stakeholders. This mutual constitution of technological and social elements is the basis of the term socio-technical system. The mutual constitution directs researchers to consider a phenomenon without making a priori judgments regarding the relative importance or significance of technological or social aspects (Sawyer & Jarrahi, 2013). Socio-technical system design is based on the premise that an organization or a work unit is a combination of technical and social parts and that it is open to its environment (Trist, Higgin, Murray, & Pollock, 1963). Because both technical and social elements must work together to accomplish tasks, the key issue of STS theory is to design work so that these two elements yield positive outcomes; this is called joint optimization.

A team in organizations is embedded in a dynamic and complex socio-technical system that influences its behavior and effectiveness. Since the early years of the STS theory, a large number of team research has been launched and based on the joint optimization principle (Molleman & Broekhuis, 2001). The joint optimization principle deals with the fact that teams endeavor to consider both technical and social aspects simultaneously. At the micro-level, there are numerous factors involved in each aspect. The technical aspect includes, e.g., the processes, tasks, techniques, knowledge and tools used in teamwork. The social aspect includes, e.g., people and their attitudes and behaviors, as well as organizational norms, rules and culture. Mostly, the idea of socio-technical coordination and/or congruence was widely proposed by researchers in software development teams (e.g., Cataldo, Wagstrom, Herbsleb, & Carley, 2006; L. Jiang, Carley, & Eberlein, 2012; Madey, Freeh, & Tynan, 2002; Sarma, Herbsleb, & van der Hoek, 2008; Valetto et al., 2007; Wolf, Schröter, Damian, Panjer, & Nguyen, 2009). Besides, the STS theory has also been applied in other fields on team research. According to Appelbaum (1997), the key principles of the STS that have contributed to our understanding of effective team design as follows: (1) overall productivity is directly related to the system's accurate analysis of technical and social needs and requirements; (2) an accurate analysis of

the technical and social needs usually leads to team designs with the following characteristics: minimal critical specification of rules, multi-skills, boundary location, information flow, support congruence, design and human values. Molleman and Broekhuis (2001) defined STS as an integral theory of work design and quality of working life. By means of the STS theory, they fon out that a kind of team design may help team achieve four different patterns of performance indicators. In other words, with a specific pattern of performance indicators in mind, they depicted a working design as contingent on these three principles. Bélanger, Watson-Manheim, and Swan (2013) explored the STS theory as a foundation for the development of the multi-level conceptual model of telecommuting. They illustrated the use of the model with data from two organizations in the high technology industry before concluding with recommendations for future research. In sum, a socio-technical perspective takes account of technical and social needs that propose ways of achieving joint optimization by designing different kinds of organizations, including team, in which the relationships between technical and social elements lead to the emergence of productivity and wellbeing.

3. Conceptual framework

Collectively, the above literature proves that the IMOI model and socio-technical perspective are appropriate for proposing a conceptual framework of virtual team effectiveness in this paper. It would be ideal to consider all socio-technical antecedents of virtual team effectiveness. However, our primary aim is to employ the value of the IMOI framework and socio-technical perspective by combining them into a conceptual framework, so we focus on some salient inputs, mediators of virtual team effectiveness relying on the joint optimization principle. Particularly, technology readiness (a team composition input) and intention to explore (a behavioral process) are two technical antecedents; team learning (a behavioral process) and a transactive memory system (a blended mediator) are two social antecedents. There is an extensive literature that has incorporated team performance as the criterion variable of interest because it has been argued that the definition of a team is that it produces something useful to an organization (Mathieu et al., 2008). In contrast to the works where performance behaviors and outcomes can be differentiated, many studies have used team performance as a composite measure of team outputs. Given that teams perform multiple functions, we use virtual team performance as a performance composite output which may be a good indicator of virtual team effectiveness. Aforesaid socio-technical antecedents are interrelated with the goal of optimizing virtual team members' performance to ultimately improve socio-technical output namely virtual team performance. In sum, there are 5 concepts and 5 hypotheses in our conceptual framework (see Figure 1).

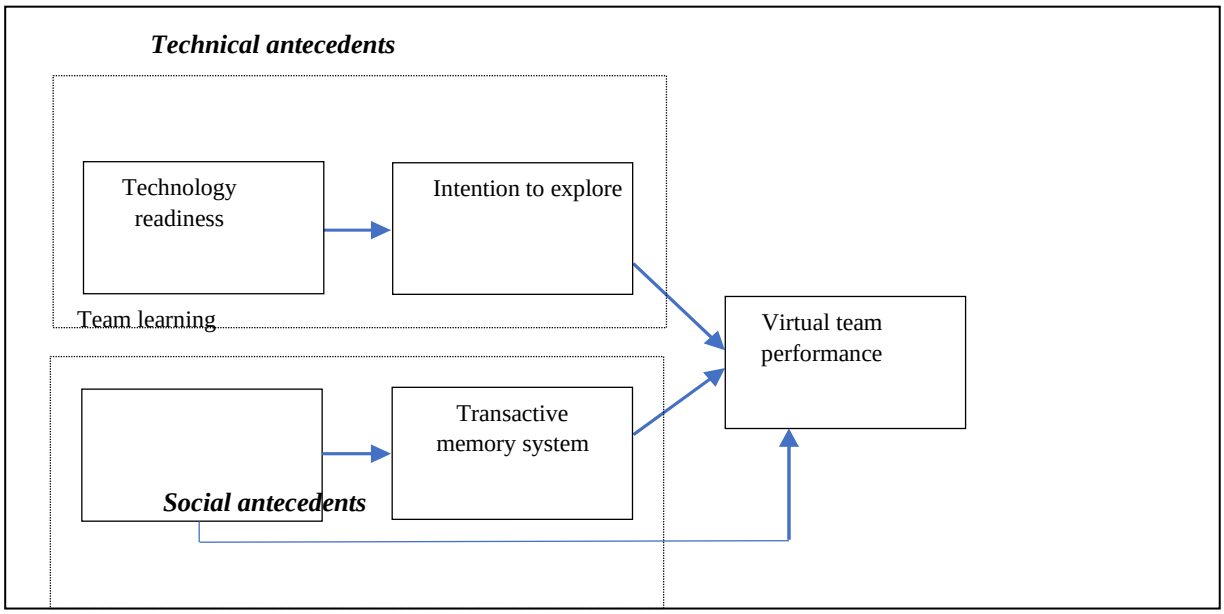

Figure 1. A conceptual framework of virtual team effectiveness under socio-technical perspective

3.1. Technology readiness: A team composition input

Among many significant antecedents of technology usage intentions and behaviors, technology readiness (TR) emerges as a concept representing people's propensity to embrace and use new technology for accomplishing goals in home life and at work (Parasuraman, 2000). The TR construct can be viewed as an overall state of mind resulting from a gestalt of mental enablers and inhibitors that collectively determine a person's predisposition to use new technology. It comprises four sub-dimensions: optimism, innovativeness, discomfort, and insecurity. (1) Optimism relates to a positive view of technology and a belief that technology offers people in increased control, flexibility, and efficiency. (2) Innovativeness refers to a tendency to be a technology pioneer and thought leader. (3) Discomfort consists of a perception of lack of control over technology and a feeling of being overwhelmed by it. (4) Insecurity involves distrust of technology and skepticism about its ability to work properly. Optimism and innovativeness are drivers of TR, while discomfort and insecurity are inhibitors. Positive and negative beliefs in technology may coexist, and people can be arrayed along a technology belief continuum from a strongly positive attitude at one end to a strongly negative attitude at the other (C.-H. Lin, Shih, & Sher, 2007).

The correlation between people's TR and their propensity to employ technology is empirically confirmed by Parasuraman (2000). Consumers' TR has a positive impact on their online service quality perceptions and online behaviors, but empirical findings are scarce (Zeithaml, Parasuraman, & Malhotra, 2002) and confounded (Liljander, Gillberg, Gummerus, & van Riel, 2006). The limited knowledge about TR constitutes a need to investigate TR in a broader framework (C.-H. Lin et al., 2007). Thus, studying TR as a team composition input of virtual team functioning could be necessary for virtual team effectiveness research. And

because of the importance of TR towards technology usage, we propose the first hypothesis: TR has a positive effect on the intention to explore collaboration tools.

3.2. Intention to explore: A behavioral process

The virtual team is more complex because its interactions are almost mediated by electronic communication and collaboration technology instead of face-to-face meetings (R. Friedrich, 2017). Technology can support good virtual teamwork and in the virtual team, the agreed and committed working processes are more important to team success (Ebrahim, 2015). Dube and Marnewick (2016) affirmed that in a virtual team, technology usage is an important aspect while team members use technology to coordinate and execute team activities. In an effort of developing the theory and offering new directions to virtual team research, with the goal of making efforts to inform organizations of enhancing the effectiveness of virtual team, they classified virtual team's mediators into four types: cognitive processes (e.g., team cognition and cognitive climate), motivational processes (e.g., teamwork engagement), affective processes (e.g., team cohesion) and behavioral processes (e.g., shared leadership, communication, and technology usage). It means that technology usage should be studied as a behavioral process of virtual team effectiveness.

Managers have had difficulty identifying potential levers that affect employees' willingness to engage in innovative behaviors with newly implemented technologies (Ahuja & Thatcher, 2005; Jasperson, Carter, & Zmud, 2005). Intention to explore is defined as one's willingness and purpose to explore new technology and find a potential use (Nambisan, Agarwal, & Tanniru, 1999) - reflects employees' propensity for engaging in exploration behavior. This intention can lead to the discovery of methods for leveraging the technology to support one's work and the result is a higher team performance (Maruping & Magni, 2012). Because of the importance of the intention to explore virtual team effectiveness, we propose the second hypothesis: The intention to explore collaboration tools has a positive effect on virtual team performance.

3.3. Team learning: A behavioral process

Since Senge (1990) proclaimed that teams, not individuals, are the fundamental learning unit in modern organizations, there has been an ongoing shift from work organized around individual jobs to team-based work systems (Devine, 1999). Teams bring diverse skills, expertise, and experience needed to tackle increasingly complex and dynamic organizational problems together. They enable more rapid and flexible responses to the technological, economic, and political pressures faced by modern organizations. In addition, teams facilitate collaboration and share knowledge across organizational, cultural, and spatiotemporal boundaries. The emergence of teams as the basic building blocks of organizations has been accompanied by growing interest in the topic of team learning (B. S. Bell, Kozlowski, & Blawath, 2012). It is our literature review to discover that in team research, the construct of team learning is usually understood as a behavioral process (Mathieu et al., 2008; Rico et al., 2010), it is said that it represents an ongoing process of reflection and action, through which teams acquire, share, combine, and apply knowledge (Kozlowski & Bell, 2008).

The virtual team offers a viable response to expertise constraints created by downsizing, mergers and acquisitions, globalization, and employee mobility preferences. Moreover, it promises new possibilities of leveraging and integrating relevant and diverse knowledge across an organization, and thus is steadily favored for accomplishing complex and nuanced knowledge work requiring multi-perspective inputs (Soule & Applegate, 2009). Virtual team members who work collaboratively, out of necessity, are more likely to gain valuable knowledge to develop their expertise hence optimizing their performance (Ebrahim, Ahmed, Abdul-Rashid, & Taha, 2011; Liu et al., 2008). Accordingly, the virtual team's ability to learn becomes remarkably important to establish and sustain effectiveness. In virtual team learning, (1) internal team learning means that team members bring knowledge, skills and experience to the workplace and attribute them to the team level; while (2) external team learning means outsourcing to solve the problems encountered by team (Edmondson & Nembhard, 2009). These rationales prove that virtual team learning should be studied as a behavioral process that leads to virtual team performance, it means that we are able to propose the third hypothesis: Team learning has a positive effect on virtual team performance.

3.4. Transactive memory system: A blend mediator

A Transactive Memory System (TMS) has been defined as the combination of individual memory systems and communications (also referred to as "transactions") between individuals. TMS is constituted by individuals using each other as a memory source. Transactions between individuals link their memory systems: through a series of processes (i.e., encoding, storing and retrieving) knowledge is exchanged between individuals and, in turn, gaps in knowledge are reduced. The majority of past studies on TMS have studied the influence of TMS on performance (e.g., Akgun, Byrne, Keskin, & Lynn, 2006; Lewis, 2004; Lewis, Lange, & Gillis, 2005; Yoo & Kanawattanachai, 2001) or have focused on antecedents that facilitate development of TMS (e.g., Akgun, Byrne, Keskin, Lynn, & Imamoglu, 2005; Brandon & Hollingshead, 2004; Moreland & Myaskovsky, 2000). Previous studies proved that TMS can play an intermediate role in the relationship of team learning and team performance.

For example, Liang, Moreland, and Argote (1995) indicated that team training and communicating can positively improve team performance primarily by creating TMS among team members; using similar experimental training conditions, Moreland and Myaskovsky (2000) argued that TMS not only mediates the relationship between training behaviors and outcomes but also improves the inter-personal communication process; conceptualizing TMS as a learning system, Lewis et al. (2005) suggested that a TMS helps members learn, both individually and collectively, as well as affect team knowledge transfer to produce sustained performance; several recent studies on TMS (e.g., Jarvenpaa & Majchrzak, 2008; Todorova, Argote, & Reagans, 2008) concluded that effectiveness of knowledge sharing among team members is dependent on the intensity of internal TMS; Z.-X. Zhang, Hempel, Han, and Tjosvold (2007) proved the mediating role of TMS in the relationship between team characteristics and effectiveness. In light of the close link between learning behaviors and team effectiveness, we propose the following hypotheses: Team learning has a positive effect on TMS, and TMS has a positive effect on virtual team performance.

4. Exploratory research

4.1. Qualitative survey

4.1.1. Methods

At first, we build up a 36-item scale of 5 proposed concepts, including 16 items adapted from Parasuraman and Colby (2015) to measure TR, 3 items adapted from Maruping and Magni (2012) to measure intention to explore, 9 items adapted from Chan, Pearson, and Entrekin (2003) to measure team learning, 3 items adapted from Yoo and Kanawattanachai (2001) to measure TMS, and 5 items adapted from Hoegl, Weinkauf, and Gemuenden (2004) to measure virtual team performance. Then we conduct 19 in-depth interviews (face-to-face or via telephone) on 19 virtual team leaders from 19 companies locating in Vietnam (Appivity System, Csc Vietnam, Dek Vietnam, DTT Vietbando, Elca, Groove Technology Vietnam, Hrboss Vietnam, Hunter Macdonald Vietnam, Phonak Operation Center Vietnam, Quantic, Saic, Vng Corp, EVNHCMC, EVN SPC, Duy Tan Plastics, Huong Ngoc Lan Cosmetics, Nguyen Minh Steels, Inox Tien Dat, Van Thanh E&I). The sample size is determined by saturation (Saunders, 2012). A semi-structured questionnaire is used. It takes about 60-90 minutes per interview.

4.1.2. Results

The first prominent result is 12/19 interviewees eliminated 8 measuring variables of 2 dimensions in TR: discomfort and insecurity. They believe that negative beliefs about technology may make them confused about the intention to explore (although these variables will be reversed). 15/19 interviewees believe that the satisfaction of using collaboration tools for teamwork is a noteworthy output that influences their intention to explore in the future. Thus, we add one more item to the scale of Hoegl et al. (2004) to measure virtual team performance: "In general, we feel satisfied with the overall experience of using collaboration tools for teamwork". The above elimination and supplement are accepted by all interviewees afterwards. Moreover, there are also some changes in using words, such as: (1) "group" is modified to "team"; (2) "my colleagues" and "team members" are modified to "my teammates"; (3) "organization" and "department" are modified to "company"; (4) "the system" are modified to "collaboration tools"; (5) "my team", "this team" and "the team" are modified to "our team". Finally, the measuring scale after a qualitative survey includes 29 variables (see Table 3).

4.2. Quantitative survey

4.2.1. Methods

A quantitative survey is conducted by means of questionnaires that contain 2 demographic questions (team type, team size) and 29 measuring questions using Likert 5-point scale. To acquire the data sample, members who work in virtual teams in 19 aforesaid companies. Convenience sampling is used, the data is collected by sending emails to respondents. 200 questionnaires are sent out and 151 are found appropriate. Data is analyzed by SPSS.

4.2.2. Results

The demographic characteristics of respondents are shown in Table 2.

Table 2

Demographics

Details	N	Percentage
Team size	151	• From 2 to 10 members: 125 (82.8%) • More than 10 members: 26 (17.2%)
Team type	151	• Software development teams: 118 (78.1%) • Other kinds of virtual team: 33 (21.9%)

Source: The researcher's data analysis

The first exploratory factor analysis (EFA) eliminates 1 indicator, namely TL6 of team learning and VTP3 of virtual team performance whereas the EFA's factor loading <0.50 (Hair, Black, Babin, & Anderson, 2013). Then, the second EFA has extracted 5 elements from 27 indicators, including technology readiness, team learning, intention to explore, transactive memory system virtual team performance. The factor loading of all indicators ranges from 0.725 to 0.912. Furthermore, the Kaiser Meyer Olkin (KMO) = 0.782; Chi-square (v2) = 212.207; Bartlett test of sphericity, dF = 136 (p = 0.000). These indexes provide that the EFA of the all observational variables is appropriate (Hair et al., 2013), so the measurement scale is valuable. Nevertheless, the total variance extracted (TVA) = 75.72% that explains the difference in the data roughly 75.72%. Besides, Cronbach's Alpha of all 5 factors > 0.6, and each indicator has an inter-item correlation >0.3 thus no indicator is eliminated and the scale is reliable (see Table 3). In sum, this 27-item measuring scale may be useful for further analysis, including confirmatory factor analysis (CFA), structural equation modeling (SEM), and Bootstrap analysis.

Table 3

Proposed measuring instrument

Factors	Measuring variables after qualitative survey		Factor loading	Cronbach's Alpha
Technology readiness	TR1	New technologies contribute to a better quality of life	0.900	0.813
	TR2	Technology gives me more freedom of mobility	0.887	
	TR4	Technology makes me more productive in my personal life	0.836	
	TR3	Technology gives people more control over their daily lives	0.810	
	TR6	In general, I am among the first in my circle of friends to acquire new technology when it appears	0.800	

Factors	**Measuring variables after qualitative survey**		**Factor loading**	**Cronbach's Alpha**
	TR8	I keep up with the latest technological developments in my areas of interest	0.791	
	TR5	Other people come to me for advice on new technologies	0.739	
	TR7	I can figure out new high-tech products and services without help from others	0.725	
Team learning	TL4	In our team, someone always makes sure that we stop to reflect on our work process	0.912	0.712
	TL3	Problems and errors in our team are never communicated to the appropriate people so that corrective action can be taken	0.886	
	TL2	We regularly take time to figure out ways to improve our work processes	0.834	
	TL1	In our team, people discuss ways to prevent and learn from mistakes	0.820	
	TL7	Our team keeps others in the organization informed about what we plan and accomplish	0.799	
	TL5	People in our team often speak up to test assumptions about issues under discussion	0.783	
	TL9	We invite outsiders to present information or have discussion with us	0.747	
	TL8	My teammates go out and get all the relevant work information they can from others, such as customers, or other parts of the company	0.726	
Intention to explore	IE1	I intend to explore how collaboration tools can be used for other tasks.	0.870	0.766
	IE3	I intend to spend time and effort in exploring collaboration tools for potential applications.	0.856	
	IE2	I intend to explore other ways that collaboration tools may enhance my effectiveness.	0.798	
Transactive memory system	TMS 1	Our team has a good "map" of each member's talents and skills	0.886	0.863
	TMS 2	Our teammates know what task-related skills and knowledge they possess	0.845	

Factors	Measuring variables after qualitative survey		Factor loading	Cronbach's Alpha
	TMS 3	Our teammates know who has specialized skills and knowledge that is relevant to their work.	0.832	
Virtual team performance	VTP5	The project leadership can be fully satisfied with the task progress of our team	0.901	0.754
	VTP1	Going by the current status, our team can be regarded as successful	0.885	
	VTP2	So far, all team goals have been achieved	0.863	
	VTP4	Our team is satisfied with its performance to this point	0.856	
	VTP6	In general, we feel satisfied with the overall experience of using ICT tools for teamwork	0.789	

Source: The researcher's data analysis

5. Conclusion

5.1. Key findings

Our first contribution is proposing a conceptual framework of virtual team effectiveness under a socio-technical perspective. By means of combining the IMOI framework with the STS theory, we focus on identifying some salient socio-technical antecedents of virtual team effectiveness. There are 5 concepts in the proposed framework, including 1 team composition input (technology readiness), 2 behavioral processes (intention to explore, team learning), 1 blended mediator (transactive memory system), and 1 performance composite output (virtual team performance). Among them, technology readiness and intention to explore are 2 technical antecedents, team learning and transactive memory system are 2 social antecedents, and virtual team performance is 1 socio-technical output which represents virtual team effectiveness. The inherent cyclical nature of virtual team functioning and the joint optimization of socio-technical factors of virtual team effectiveness are reflected through multi-relationships between these factors. Besides, our second contribution is proposing a 27-item measuring instrument by adapting previous scales and conducting a qualitative survey of 19 virtual team leaders and a quantitative survey of 151 virtual team members from 19 companies locating in Vietnam. These results can be used as references for those interested in improving virtual team effectiveness.

5.2. Further developments

The recent development of this paper is exploiting data by CFA, SEM and Bootstrap analyses. Moreover, further developments are: (1) make a broader and deeper literature review with more reference documents to explore more interesting factors that represent socio-technical antecedents of virtual team effectiveness; (2) conduct larger qualitative research on more representative sample to modify measuring variables; (3) carry out quantitative research

with probability sampling and afterwards use various data analysis tools to verify the research model. The resultant research model with high reliability and validity can be applied widely for measuring and checking virtual team effectiveness in Vietnam through its verified socio-technical antecedents.

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