Developing and Validating a Socio-Technical Model for Geographically Distributed Collaboration in Global Virtual Teams

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Abstract

As technological developments continue to enable broader adoption of geographically-distributed collaboration practices in academic, industrial, governmental, and non-profit organizations around the world, it has become critical for scholars and practitioners to be able to assess and predict the effectiveness of virtual organizations (VOs) and the global virtual teams (GVTs) that comprise them. This study provides a comprehensive review of the literature on the social and technical factors thought to influence VOs and GVTs, and proposes an integrative ten-factor sociotechnical model for their study and implementation. We then use computer-assisted content analysis to validate the model on a large sample of interdisciplinary literature. Finally, we provide recommendations for further empirical testing of the model on existing virtual organizations. From this work, we hope to encourage a more comprehensive understanding of the social and technical factors affecting VOs.

1. Introduction

Modern work and social life are characterized increasingly by information collection, exchange, collaboration and communication mediated by computer technology. Individual as well as work-team activities are frequently facilitated by the ease of access to information and collaborators networked across long distances. Virtual organizations (VOs) and the global virtual teams (GVTs) that comprise them, illustrate that in many ways collocation is no longer the sine qua non of collaboration.

However, despite the rapid growth of distributed collaboration, research that integrates insights and analyses about the social and technical characteristics of VOs and GVTs across multiple disciplines is limited.

The purpose of this paper is to develop and validate a model of factors influencing the effectiveness of virtual organizations and global virtual teams. It does this by conducting a comprehensive review of the interdisciplinary literature (e.g. psychology, sociology, management, CSCW, CMC, and information science) exploring the social and technical factors influencing virtual organizations and global virtual teams. This model is then validated using computer-assisted content analysis on a large-scale database of interdisciplinary literature on VOs and GVTs.

2. Virtual organizations, a definition

We assume that social, organizational, informational, and technological factors are all collectively influencing the function of the organization along with communication and culture. Thus we argue the study of VOs should be done from a multidisciplinary perspective. Toward this end, we adopt Cumming’s [8] definition of VOs as our starting point: "a group of individuals whose members and resources may be dispersed geographically and institutionally, yet who function as a coherent unit through the use of cyberinfrastructure (CI)." In this respect, we regard VOs as having two main characteristics, (1) they maintain their structure without sharing a physical space and, (2) they use computer-mediated communication to function.

3. A foundation on a five-point model

The Theory of Remote Scientific Collaboration (TORSC), derived from National Science Foundation (NSF) studies in the fields of collaborative communication and the sociology of science as well as from the Science of Collaboratories (SOC) project identifies five major clusters of socio-technical
components that are important for successful remote collaboration [40]. (1) The nature of work, (2) level of common ground, (3) collaboration readiness, (4) management, planning and decision-making and (5) technology readiness. These factors highlight distinct but inter-related areas important in evaluating VOs.

The nature of the work being conducted; refers to the coordination of workflow. Coordination can be categorized into three basic phases [53]: (1) standardization implies that consistent routines are established to organize work in modular or autonomous working groups; (2) coordination by plan is based on the assumption that work groups coordinate and readjust work based on scheduled meetings and evolving task goals; and, (3) coordination by mutual adjustment, requires ongoing feedback and adjustment. The latter, also called reciprocal interdependence means that “the actions of each position in the set must be adjusted to the actions of one or more others in the set;” also, it “involves the transmission of new information during the process of action [53]. This third type of work is referred to as “tightly coupled,” emphasizing that such work is vulnerable in virtual collaborations because distance poses an obstacle in accommodating quick, rich communication, contextual understanding, and firm grounds for decision-making [40].

Level of common ground, which can be thought of as the shared mental models that team members have about their work; this component provides the means to standardize group expectations and consists of experience gained through previous collaboration, a common vocabulary, and similarities in working style [40]. Workers succeed by orienting themselves to the group norms, and by developing common ground, “collaborators gain mutual knowledge, beliefs and assumptions and know that they have this” [40]. Ultimately common ground is a cognitive framing device for each collaborator to make sense of his or her role in the context of the group’s work.

Collaboration readiness, based on both work and social dimensions of the collaboration, reflects the extent to which collaborators are motivated to work together and are aligned in work processes and goals [2]. The work dimension refers to working styles and behaviors, and how team members reconcile their differences to take advantage of emerging opportunities or sort out obstacles. The social dimensions of collaboration readiness focus on concepts of motivation, trust, and efficacy [40]. Collaborators are motivated if they have something to gain, in terms of making an individual contribution and in perceiving the value of leveraging disparate skills towards a common goal. Efficacy includes self-efficacy, group efficacy, as well as the ability to surmount obstacles. Aspects of trust include whether others can be trusted to keep their promises, whether the quality of collaborators’ work will be high, and whether collaborators can be trusted to not take advantage of others’ vulnerabilities [40].

The management, planning and decision making component governs physical and logistical working procedures that contribute to successful VOs. It addresses issues related to time, planning, communication, project management preferences, team composition, and management styles. This component stresses the need for developing governance documents, doing contingency, communication and strategic planning, practicing knowledge management and implementing appropriate leadership and decision-making according to the needs and characteristics [40].

The technology readiness component on one side concentrates on the organizational technological infrastructure and information and communication technology (ICT) suitability. The user side of technology readiness addresses user efficacy and assumes that collaboration tools provide optimal functionality and benefit, they are easy to use, user-centered and reliable, it also assumes there is agreement about which technologies are most useful. On the management side, technology readiness requires a networking infrastructure, interoperability assurance, technical support, coordination, and policies for data sharing, access, and security [40].

Although the TORSC model [40] identifies several important functions of VOs, we find the specification of the five components to be overly narrow. The TORSC five-component model merges several distinct constructs that have been examined as exclusive concepts in the social, information, and organization science literature. For example, different subtypes within the nature of work category have different implications for the effectiveness of VOs. Also, [54] suggests that economic motivations are critical to corporate VOs and perhaps to other forms of VOs as well. It is possible that the TORSC five-factor model might mask some of these subtleties [40]. Developing a finer grained model, which is also supported empirically, might better illustrate the specific conditions under which VOs succeed or fail.

Based on our initial reading of the literature and experience in building VOs in the sciences, social sciences, industry, and transnational civil society, we propose a 10-factor model that builds upon the five-factor model [40] by: 1) specifying more precisely defined variables, 2) adopting terminology that allows for connection to an interdisciplinary audience, and 3) incorporates issues related to accessibility.
4. Our ten-factor multidisciplinary model

The proposed conceptual model includes ten interdependent socio-technical factors, and specific dimensions of those factors. While we recognize the intense interaction between these variables, for the purpose of classification, these factors are labeled as either technical or social-organizational factors.

Figure 1. Socio-technical conceptual model

4.1. Technical factors

For years, technology has been seen as critical to the success of VOs [1, 56]. Recently, the term cyberinfrastructure has gained traction, even in describing VOs beyond its physical sciences and engineering roots. Cyberinfrastructure depends heavily on both social and technological factors.

4.1.1. Telepresence. Telepresence is an environment created by means of an electronic communication medium; as opposed to the concept of presence, which is defined as “the sense of being in an environment” [48]. Telepresence is the extent to which one feels present in the computer mediated environment, rather than in the immediate physical environment [48]. The earliest formal use of this term is attributed to Minsky [38]: Telepresence emphasizes the importance of high-quality sensory feedback and suggests future instruments that will feel and work so much like our own hands that we won't notice any significant difference. Thus the communication medium could take the form of any number of technologies, such as telephone, video, virtual reality, a robotic arm, etc.

Telepresence implies an extremely close approximation of a familiar physical location and the projection of presence into the computer-mediated environment (the “tele” aspect). Presence, as explained by Lombard and Ditton [33], has two characteristics. The first one is presence as social richness, or “the extent to which a medium is perceived as sociable, warm, sensitive, personal or intimate when it is used to interact with other people” Lombard and Ditton online [34]. The second characteristic is the degree to which a medium can produce a “seemingly accurate” representation of the world, or presence as realism. Lombard and Ditton [33] emphasize that there are two types of realism: social realism, the extent to which events in a portrayal seem “true to life;” and, perceptual realism, where the objects portrayed seem “true to life.”

When perception is mediated by a communication technology, one is forced to perceive two separate environments simultaneously: the physical environment in which one is actually present, and the environment presented via the medium. In the context of VOs, telepresence impacts the way in which people interact and the way work is accomplished. Minsky [38] suggests though, that (pending the use of well-designed tools) “we won’t notice any significant difference” between the natural state and the mediated state. It is in this idea where the relation of telepresence to VOs rests.

4.1.2. Digital literacy. This term is closely related to life-long learning, the ability to use information, and the use of information technology. There is an information component to digital literacy and a technology component. The American Library Association defines information literacy as the ability to recognize when information is needed and the ability to locate, evaluate, and use effectively information.”[45] In this sense the technical aspect of digital literacy would refer to individuals’ information literacy while using specifically digital technology.

4.1.3. Technology scaffolding. Scaffolding is a classic education technique that allows students to progressively build skills by executing a task with the help of a more knowledgeable guide or facilitator Jackson, Krajcik, and Soloway [27] suggest that scaffolding can be an effective training method to build the skills of basic and advanced users of digital information systems. Scaffolding consists in engaging a student/trainee in a task above his/her skill level, an instructor would intervene to help
through the task when necessary with decreasing frequency as student's knowledge increase and until he/she is comfortable using the technology independently[30]. Gupta and Bostrom [17] go on and suggest that when scaffolding is used in concert with observational modeling, a technique where a user observes and imitates behaviors of an instructor while s/he completes a task, a number of benefits can come as a result. (1) It increases student confidence in their ability to use technology (self-efficacy), which will allow them to expend more effort than their counterparts to fill recognized skill gaps [7]. (2) It improves understanding of the use of information technology to achieve objectives [36]. (3) It can quickly develop a user's ability to use novel collaboration and communication technologies effectively with minimal support from instructors. Having a critical mass of users who can independently use information technologies to access people, resources, and facilities is essential to VOs.

4.1.4. Accessibility/Universal Design. One of the key advantages of a VO is its ability to provide a group of geographically distributed people access to information, resources and other people. Cyberinfrastructure designed with accessibility in mind allows all individuals including those with disabilities to have access to these resources, directly or through the use of assistive technology[35][18].

However, in the main, VO designers have paid insufficient attention to the needs of people with disabilities. Burghstahler [3] explained that persons with disabilities can, and in a majority of situations do, face a second level of digital divide by being unable to use commonly existing technological tools even if they have, access to them. In order for VOs to reach their full potential, they will have to pay closer attention to international frameworks and U.S. legal mandates for accessibility, and to universal design (UD) principles. UD refers to the creation of products and environments, as well as practices, programs, and services, that are accessible to and usable by all persons, including individuals with disabilities, without adaptation or specialized design [53, 39]. In 2004, Congress codified UD into federal law by passing the Assistive Technology Act (29 U.S.C.A. § 3002, 2005), although they did not specifically mandate its use in public or private research.

4.2. Social factors

4.2.1. Trust. Much of the recent work on VOs has been devoted to developing a clear and relevant definition of trust. Trust is generally accepted to be a factor that functions at multiple levels within a social system [43]. For instance, individuals might hold general tendencies to trust people. Also, trust might differ across one-on-one relationships. At a higher level, members of a VO or GVT might develop a sense of trust of the leadership or organization as a whole. We take into consideration the implications of trust in VO effectiveness and goal achievement. As a starting point we employ Mayer’s definition of trust [37]: “the willingness of a party to be vulnerable to the actions of another party based on the expectation that the other will perform a particular action important to the trustor, irrespective of the ability to monitor or control that other party (p.712)”.

From Davenport [9, 10] we incorporate the concept that trust encourages individual contributions to team and organizational goals. Considering that trust is traditionally built upon physical interaction [20], we also draw upon scholars who stress that the long-distance status of GVTs makes trust between members difficult, but a very important factor for effectiveness [28]. Jarvenpaa [29] ponders the importance of face-to-face interaction and its effect on trust dynamics and effectiveness. Olson and Olson [41] suggest trust is a function of the cues provided by social partners, thus contexts closely resembling FTF interactions will likely foster greater trust.

4.2.2. Leadership. The literature on leadership indicates perceived leadership characteristics as determinants for effectiveness in distributed teams [22]. According to Yamaguchi [58] leaders of effective distributed teams take early initiative in tasks; maintain a positive outlook and communicate regularly with other members. On the other side in unsuccessful distributed teams “email questions go unanswered, important process questions are never addressed, and other leadership functions are unfilled” [58]. The effectiveness of communication in VOs and GVTs is also positively associated with the number and quality of informal relationships that colleagues have with one another [57]. In terms of challenges faced by leaders of virtual teams, Cascio & Shurygailo [4] identified six: (1) Keeping tight and loose controls on intermediate progress toward goals; (2) Promoting cooperation among teams and team members in order to integrate deliverables; (3) Encouraging and recognizing emergent leaders. Yamaguchi [58] studied emergent leadership based on Stogdill’s leadership behavior descriptor questionnaires [50], [51] [52]. The first classification was “task-focused leadership” and the second was “relationship-focused leadership”; (4) establishing explicit processes for archiving important written documentation; (5) establishing and
maintaining norms and procedures early in a team’s formation and development; (6) establishing proper boundaries between home and work. To address some of these challenges, Cascio [4] suggests that leaders should (1) set initial face to face meetings and team-building exercises, (2) establish norms for the frequency of communication and reasonable deadlines for task completion, and (3) schedule regular status meetings to check on the progress of tasks. The effectiveness of a VO hinges greatly upon the presence of leadership and his/her ability to promote and engage in practices that establish team norms, facilitate relationship building and develop trust. In addition, distributed leadership [12, 16] and shared leadership [32] are seen as critically to facilitating effectiveness in VO.

4.2.3. Social System. Social system refers to the way in which individual members within an organization relate to each other and to the organization as a whole. Social systems within virtual organizations share many characteristics with organizations that are maintained in common physical space. However, social systems within virtual organizations demonstrate some uniquenesses that accommodate communication in virtual or long-distance collaboration. The development of the social system involves a social negotiation among individuals and between each individual and the organization. Individual members must develop a common understanding of objectives and contextual gaps in the transfer of information should be minimized [14]. Cooperation produces socially efficient outcomes [31], results in better performance on tasks of collective induction and substantially higher rates of collaboration in social dilemma tasks. Despite these benefits, there are inherent risks in cooperative strategies and, therefore, a certain level of trust is necessary for individuals to willingly become vulnerable [44]. In essence, individuals want to feel that their investment of time, energy, and information in a cooperative venture will not be squandered.

4.2.4. Collaborative learning. Computer Supported Collaborative Learning (CSCL) appears in several areas of research; Hsiao [24] points out it is the convergence of Computer Supported Cooperative Work (CSCW) and Collaborative Learning theories. From this perspective then CSCL can be defined as computer-based network system that supports group work providing a shared interface for them to work [13]. Hsiao [24] highlights the differences are based on the setting; while CSCL takes place on a learning/teaching/educational setting, CSCW does it on a professional setting. However beyond the setting, there are educational principles on which CSCL is founded. First of all, CSCL draws from constructivist approaches to learning: “Collaborative Learning”, “Problem-Based Learning” and “Communities of Inquiry” in which students engage actively in a discovery process and “collaboratively construct meaningful and worthwhile knowledge” [15]. CSCL also draws from cognitive psychology research, which affirms the proliferation of knowledge is the result of a “constructive and collaborative process by which two or more individuals collectively focus attention, thus collectively construct and relate episodes” [4]. It’s important to point out that CSCL intends to scaffold and support student learning, group processes and group dynamics in ways that are not achievable by face-to-face. CSCL does not intend to replace face-to-face communication [24]. Cogburn [6] regards CSCL as a mechanism to facilitate global knowledge, which would not only complement FTF collaboration, but would enable global communities of practice and learning communities to emerge. CSCW researchers argue that online learning may have an advantage in supporting collaboration and creating a sense of community, however incorporating the principles of the community of inquiry model to the computer-supported educational experience implies the inclusion design, facilitation and direction [24] elements in the design of VO.

4.2.5. Culture. While many scholars view culture as the essential element between groups of people that facilitates communication and knowledge sharing, it is a notoriously complex concept. Hofstede [21] defines culture as ‘the collective programming of the mind which distinguishes one group or category of people from another. Hall's [19] research on culture led to the discovery of national cultures that have “high” or “low” context communication styles. Hall affirms that people from high context cultures depend on nonverbal signals and cues to communicate, while those who prefer low context styles focus on rely heavily on verbal or written communication. Ardichvili [2] has studied how culture affects knowledge sharing in a physical and a virtual context using Hall and Hofstede’s frameworks. Ardichvili [2] argues that individuals from a culture with a preference for high context communication will tend to prefer rich media (webconferencing, video) to interact with their colleagues; and people from cultures with a preference for low context communication styles may gravitate toward leaner media (chat, e-mail, discussion boards) in CMC environments. Studies have also shown that the use communication tools with high media richness
facilitate the creation of common ground with visual cues and gestures, thus helping bridge cultural differences or language barriers amongst different groups [55]. Taking cultural differences into account in the design of VOs could increase the participation and knowledge sharing by people around the world.

4.2.6. Motivation. Motivation refers to the reason for people to engage in a particular behavior. The management, psychology, and lately information science literature identify motivation as an important social aspect to organizations and learning. Most cognitive-based literature distinguishes two sources of motivation: internal (intrinsic) and external (extrinsic). Intrinsic motivation is related to informational rewards; or the satisfaction to learn something new; whereas external motivation is related to “controlling” rewards, achieving recognition or advancing a career. Small [46] argues that Keller’s ARCS model [25, 26] can be applied to instructional design in work and collaborative environments. Therefore organizational design should incorporate elements to increase: (1) Attention: to increase curiosity and interest, (2) Relevance: likelihood that a task satisfies needs, motives or values, (3) Confidence: feeling of competence and confidence (need to share control over tasks), and (4) Satisfaction: Extrinsic and intrinsic reinforcement. Similarly, Small and Venkatesh [47], suggest that the satisfaction a person obtains from making a decision is an intrinsic motivation to learning. Drawing from Stewart [49] they claim instructional methods and technologies should encourage information process and analysis in order to foster better decision-making skills, improve learning outcomes and promote intrinsic motivation. Motivation has implications for team building, trust, collaborative learning, management, leadership, and digital literacy; which have been identified by Hollan and Stornetta [23] as crucial for understanding and designing VOs. As a result, intrinsic and extrinsic motivation becomes crucial to effective VO design.

5. Methodology for validating the model

We believe this ten-factor model of socio-technical influences on VOs and GVTs is more comprehensive than the TORSC approach. However, we wanted to validate this model against a carefully selected sample of the existing interdisciplinary literature. To do so, we developed a mixed methods meta-analytical approach. Our goal was to identify a representative sample of relevant literature from the relevant disciplines identified in previous studies. To kick this off, our interdisciplinary team of faculty and doctoral students met weekly in a seminar on Virtual Organizations as Socio-Technical Systems (VOSS Seminar). The VOSS Seminar allowed us to engage in a “level setting” phase of the project. After this level setting phase, and developing the initial conceptual model, we engaged in a systematic collection of literature drawn from the leading peer-reviewed journals and conference proceedings in the fields of CSCW, CMC, CSCL, IS, management, psychology and other social sciences.

To prepare this dataset, all PDFs were converted to RTF files. Our literature dataset (n=1,186) is composed of journal articles (86%), conference proceedings (11%), monographs (2%), book sections (0.5%) and other (0.5%).

We used a computer-assisted content analysis tool called WordStat (http://provalisresearch.com/) to explore this dataset deductively and inductively. Deductively and structurally, we took each concept in the conceptual model (e.g. trust) and defined the variable based on the existing literature, identified related literature, highlighted the subtle distinctions found in the literature related to the concept. When then used those to refine our search criteria on each term. We used these initial findings to build a classification model based on keywords that included all of the ten dimensions represented in our initial conceptual model. The goal for this part of the qualitative meta-analysis was to determine the degree to which our ten factors were present in the dataset.

Inductively, we used “keyword” frequency by case occurrence and “phrase finder” by case occurrence, to identify concepts that were “important” in the dataset, but not yet in our model.

6. Preliminary results

We find that out of our ten concepts, none of them show up directly in the frequency count, but most show up indirectly (e.g., management for leadership).

![Figure 2. Most frequent words in the dataset](http://example.com)
However, when we explore the keyword frequency using the ten concepts from our classification model (which does not just use keyword but related words) we find that all of the ten concepts in our model are represented in the literature to varying degrees, with the “social system” variable being the most represented, followed by “leadership” then “trust.”

![Figure 5. Keyword frequency distribution](image)

Figure 3. Model dictionary classification

When exploring the similarity index, we see several variables from the model that are closely related, especially “leadership” and “social system;” followed by “technology scaffolding;” then “digital literacy;” then “trust” which all have a Phi Coefficient close to 1 (the closer to 1 the cluster is, the more related the variables are).

![Figure 4. Model keyword similarity index](image)

Figure 4. Model keyword similarity index

Finally, we took a completely inductive approach, to determine of other “important” words or concepts were present in the dataset that were not present in our initial model. In the keyword frequency distribution, we find “information,” “members,” “communication,” “time,” “project,” and “task.” This finding suggests the possible addition of and “information and communication” dimension and a “time/project/task” variable.

From the phrase finder, we only find “activity theory” and “social network” that are not explicitly covered in the existing model, and both can be incorporated.

![Figure 6. Phrase by case occurrence](image)

Figure 5. Keyword frequency distribution

### 7. Discussion and conclusions

The conceptual socio-technical model for the study and design of virtual organizations we present in this paper, is clustered around ten themes that we believe will contribute to an enhanced understanding of the factors and dynamics influencing the study, design and effectiveness of virtual organizations. Our ten-factor model reflects most of the key concepts present in the literature. This model also fosters the development of a repeatable methodology for collecting empirical data on virtual organizations and global virtual teams.
However, we have seen some concepts in the model receive far less attention in the literature, especially “accessibility” and “motivation,” but also “technology scaffolding,” “digital literacy,” and even “culture.”

This study highlights the complex relationship between technology factors and social factors and points to the need to address the socio-technical gap [1] between what people need to collaborate and what technology can provide. The literature cited here addresses team building, management, leadership, and digital literacy as, identified by Hollan and Stornetta [23], which are crucial for understanding and designing VOs. In addition we included literature from the social and information sciences on interrelated social and technical factors (referred to in this paper as: trust, leadership, collaborative learning, social systems, culture, motivation, technology scaffolding and universal design) that have a fundamental impact in the way people collaborate virtually.

For organization purposes we initially divided the concepts in two groups, technical factors and social factors. From our literature examination we found clear relations amongst technical factors. For instance, digital literacy, as the ability to find, retrieve, and evaluate information, is closely related to the abilities technology scaffolding provides people to be digitally literate. Another relation we identified is the relation between universal design and the amount of training people may need to use a technology.

We also identified strong relations amongst social factors. For instance, Small’s articles on motivation have a strong tie to Collaborative Learning, several of the Motivating techniques she proposes are to promote intrinsic motivation (satisfaction with decisions, learning as a reward, etc), which is the most important type of motivation that people in communities of practice have to join them. Another example is Jarvenpaa and Leidner [28] observation on teams exhibiting high levels of swift trust had rotating or emergent leadership. Teams with lower measurements of swift trust showed little or no leadership, and communicated with less frequency and effectiveness than the high trust teams. In terms of trust and culture Jarvenpaa and Leidner [28] argue that people from individualistic cultures are more likely to be trusting of people who share their national culture. Ardichivili [2] makes a similar assertion that individuals from collectivist cultures like China and Russia will be more likely to share with individuals from similar cultures.

Olson, Teasley, and Bietz [42] argue that if a user has little or no familiarity with “simple” collaboration technologies (data repositories and group calendars), then s/he will not be able engage in more advanced processes (e.g., the creation of a data repository and handoff collaboration [42]. We find this statement to closely relate motivation to digital literacy, technology scaffolding, and trust.

Our next step in the study is to integrate the findings from our quantitative meta-analysis into the revised model, and then finalize the web-based survey instruments to empirically test to ten-factor model on four existing virtual organizations.

Considering the potential impact of VOs on broadening participation in scientific research around the world, enhancing employment and research opportunities for people with disabilities, and increasing economic competitiveness; we propose further research to be pursued around the following questions: (1) universal design and accessibility in the study of VOs; (2) the interdisciplinary knowledge and skills necessary to support VOs; (3) The socio-technical factors that most significantly influence the diffusion of VOs (4) the types of activities that are most common and unique amongst VOs (5) the impact of the VO on effectiveness and productivity; (6) integration of VOs to the larger organizational ecosystem; (7) the role of leadership in the acquisition of digital literacy; (8) and the socio-technical dynamics of knowledge sharing and socialization for virtual collaboration. Answering these questions would advance the identification of social and technical dynamics that influence the design, development, and evaluation of VOs.

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9. References


