

CULTURAL CONSIDERATIONS IN COMPUTER SUPPORTED COLLABORATIVE LEARNING

RAVI K. VATRAPU

*Department of Information and Computer Sciences
University of Hawaii, Post 317, 1680 East-West Road
Honolulu, Hawaii 96822, USA
vatrapu@hawaii.edu
<http://lilt.ics.hawaii.edu/~vatrapu/>*

This paper reports on a theory-based empirical investigation of cultural considerations in the appropriation of affordances and on the development of technological intersubjectivity in a computer supported collaborative learning environment. Socio-technical affordances are “action-taking possibilities” and “meaning-making opportunities” in a socio-technical system relative to the capabilities of an actor. Technological intersubjectivity is a technology-mediated interactional social relationship between two or more participants. The basic premise of this research project is that social affordances of technologies vary along cultural dimensions. To empirically evaluate this premise, an experimental study was conducted. The experimental study design consisted of three independent groups of dyads from similar or different cultures (American-American, American-Chinese, and Chinese-Chinese) doing collaborative problem-solving in a knowledge-mapping learning environment. Participants interacted through an asynchronous computer interface providing multiple tools for interaction (diagrammatic workspace, embedded notes, threaded discussion). Based on theories of culture and empirical findings in cultural psychology documenting cross-cultural variations in behavior, communication and cognition, several research hypotheses were advanced. Statistical results show that members of different cultures appropriated the resources of the interface differently in their interaction, and formed differential relations with and impressions of each other. However, analysis of the individually written essays show no statistically significant differences in learning outcomes. Implications for technology enhanced learning are discussed.

Keywords: Affordances; perception of affordances; appropriation of affordances; computer supported collaboration; computer supported collaborative learning; culture; technological intersubjectivity.

1. Introduction

The basic premise of this research project is that socio-technical affordances vary across cultures. In order to test this basic premise, the research project reported here, empirically investigates the cultural influences on appropriation of affordances and on technological intersubjectivity in a computer supported collaborative learning (CSCL) environment. The primary purpose of this paper is to conduct an empirical evaluation of cultural considerations in how participants (a) appropriate the

affordances, (b) interact with and relate to each other, and (c) perform on assessments of individual learning outcomes.

1.1. *Central concepts*

In the next few paragraphs, the central theoretical notions for this research project — affordance, culture, representational guidance and technological inter-subjectivity — are introduced and briefly discussed.

1.1.1. *Affordance*

The notion of affordance was first introduced by the ecological psychologist John J. Gibson (1979). Gibson viewed affordances as relational properties between an organism and its environment. Technology affordances (Gaver, 1991; Suthers, 2006) are properties of the technology environment that provide action possibilities to users given their action capabilities. Social affordances (Bradner, 2001) are affordances for social interaction. Socio-technical affordances are affordances for social action in a socio-technical system relative to an actor. Both actors and “actants” (Latour, 2005) are implicated in the concept of socio-technical affordances. Briefly, socio-technical affordances are “action-taking possibilities” and “meaning-making opportunities” in a socio-technical system relative to the action capabilities and meaning competencies of the actor.

1.1.2. *Culture*

The concept of culture has a checkered intellectual history. Raymond Williams (1983, p. 87) has termed culture “one of the two or three most complicated words in the English language.” According to Williams (1977, p. 11), the concept of culture, “at once fuses and confuses the radically different experiences and tendencies of its formation.” Culture has been defined in different ways by different researchers. Different definitions of culture reflect different theories for describing, understanding, explaining or valuing human thought, activity, discourse and subjective experience (cf. Vatrapsu & Suthers, 2007). This research project uses Hofstede’s (1997, p. 5) definition of culture as “the collective programming of the mind which distinguishes the members of one group or category of people from another.”

The emphasis in Hofstede’s definition is that culture is learnt in nurture and not inherited by human nature. The “collective programming of the mind” highlights culture as a collective activity that is to be conceived as a dynamic process rather than a passive state. The other part of the definition “which distinguishes the members of one group or category of people from another” points out the individual and group identity formation and sustenance aspects of enculturation in social institutions like family, school, and work. Culture comes from a perceived similarity of individuals within a cohort group (be it a linguistic community, an ethnic group or a scientific community) and in that sense it is collective. This similarity

is not intended to be exact; neither does it imply essentialist homogeneity. In a multicultural society, culture is about a collective particularity.

Hofstede (1997, p. 18) relates “collective programming” to Bourdieu’s (1977) notion of “habitus”. Hofstede’s definition is interpreted in this research project from the Vygotskian socio-cultural perspective of the “social formation of the mind” (Wertsch, 1985). “Collective programming” is not to be understood as an external imposition but an active social and ecological composition in which the particular individual plays the protagonist. Taken together, “social formation” and “collective programming” of the mind are conceptualized as a cultural schema. This conception of cultural schema is based on Bartlett’s seminal formulation of schema theory and its subsequent elaborations (Saito, 1999). Contra interpretive anthropological (Geertz, 1973) and Cultural Studies (Barker, 2003; but also see Cusset, 2008, pp. 133–138; Eagleton, 2000; S. Hall, 1996) views of culture as a symbolic text, the conception of culture as a schema is concerned with accounting for cultural cognition in actual interactions that unfold in real-time and in real-space. Linking up to the concept of affordance defined above, the conception of culture as a schema is concerned with how action-taking possibilities and meaning-making opportunities systematically vary between different collectives (ethnic, linguistic, professional, practitioner, hobbyist etc.).

1.1.3. *Representational guidance*

A computer supported collaborative learning (CSCL) environment based on Suthers’ (2001) research program of representational guidance was used in the research study. The construct of representational guidance has tripartite origins: the affordances of representational notation, the actualization of that notation in representational tools such as software, and the actual configuration of representational artifacts created by the users.

CSCL is a “field of study centrally concerned with meaning and practices of meaning-making in the context of joint activity and the ways in which these practices are mediated through designed artifacts” (Koschmann, 2002, p. 17). Inquiry based learning (Dantonio & Beisenherz, 2001) is a pedagogical paradigm influenced by John Dewey’s highly influential educational vision (cf., Dewey, 1902/1956, 1938, 1938/1991). Koschmann (2002) identifies Dewey’s conception of inquiry as the theoretical core of CSCL and points out that “inquiry” for Dewey was a rich representation of an “exceedingly broad category of activity” (p. 19). In CSCL environments, Koschmann emphasizes the importance of the “indeterminate situation”, its transformation through the processes of inquiry into a holistic entity and its “subsequent reabsorption into the background of experience” (p. 19), leading to a successful problem solving activity. Koschmann (2002) bridges Dewey’s insights to CSCL by stating that “the forms of joint problem solving that we study in CSCL are a species or special case of Deweyan inquiry” (p. 19). This research problematizes the nature of interaction when the “indeterminate situations” of problem

solving involves and requires intra- and inter-cultural collaboration. This research seeks to evaluate cultural effects in computer supported collaborative learning settings, and is grounded in empirical findings demonstrating cultural differences in cognition (Nisbett, 2003), communication (Hall, 1977), behavior (Hofstede, 1997; House, Hanges, Javidan, Dorfman, & Gupta, 2004), traditional schooling and learning (Hofstede, 1986), and online learning (Hewling, 2005).

Suthers (2006), building on Koschmann's (2002) influential definition of CSCL, emphasized the centrality of intersubjective meaning-making to collaborative learning and provided a working definition of intersubjective meaning-making as "joint composition of interpretations of a dynamically evolving context" (p. 315). This research investigates the processes and products of computer supported collaboration when intersubjective meaning-making is inherently intra- and inter-cultural.

1.1.4. *Technological intersubjectivity*

Technological intersubjectivity (TI) is an emergent phenomenon in socio-technical systems. Technological intersubjectivity (TI) is a technology-mediated interactional social relationship between two or more participants. Sometimes in TI, the actors' subjective presence is more salient than the mediating technology. TI is essentially about the experience of being with others through technology supported interactions. Such an experience is supported by information and communication technologies (ICT). ICT support various computer-mediated communication (CMC) tools, computer supported cooperative work (CSCW) and computer supported collaborative learning (CSCL) environments. CSCW and CSCL environments not only support communication but also mediate artifact centered collaboration. Together these technologies support a variety of interactional purposes and processes. These interactional purposes and processes constitute both resources and topics for an emergent interactional association between participants and artifacts. As a construct, technological intersubjectivity consists of the dynamic interplay between the functional relationship of participants as communicators and empathetic relationship of participants as actors.

To put it differently, technological intersubjectivity refers to the range of phenomena in the interactional dynamics between protein beings and silicon machines (Dennett, 2007). Notions related to TI include "networked individualism" (Castells, 2001), "information subject" (Poster & Aronowitz, 2001), "time-space compression" (Harvey, 1989), and "presence" (Lombard & Ditton, 1997). With the exception of research literature related to "presence" in online environments (Lombard & Ditton, 1997), the study of technological intersubjectivity remains outside the core concerns of technology design in applied computer science in general and technology enhanced learning in particular.

1.2. *Research problem*

Early online education practice has in many aspects treated the Internet as yet another delivery platform. By extension, the computer was treated as a passive

node on the network sending and receiving instructional content (Moore, 2004). Asynchronous learning networks (ALN) research emphasizes interaction and learning communities (Hiltz, 1994; Moore, 2004) whose theoretical underpinnings are related to Manuel Castells' (2001) notion of "networked individualism." The Internet is currently undergoing a profound shift towards a participatory mode of interaction privileging social sharing and group collaboration. It is time to think beyond the text-based discussion boards of a typical online classroom. It is time to think through the thicket of problems that arise from the pedagogical promise of computers in the era of globalization.

The dynamic interdependence of considerate social behavior, meaningful cognitive engagement and innovative pedagogy is John Dewey's critical insight. Dewey's educational vision calls for a necessary conjunction of "experience", "inquiry" and "curriculum" (1902/1956, 1938, 1938/1991). As such, educational technology paradigms based on social constructivism (such as CSCL) emphasize three interdependent aspects of learning: social behavior, cognitive processes and pedagogical technologies. However, four distinct lines of empirical research have demonstrated that:

Culture influences social behavior (Hampden-Turner & Trompenaars, 1998; Hofstede, 1997; House *et al.*, 2004);

Culture influences communication (Hall, 1977)

Culture influences cognitive processes (Dimaggio, 1997; Nisbett & Norenzayan, 2002; Ross, 2004); and

Culture influences interacting with computers; human-computer interaction (HCI) research has shown that culture influences *user interface design* (e.g., Fernandes, 1995), *web design* (e.g., Marcus & Gould, 2000) and *usability evaluation* (e.g., Vatrupu & Pérez-Quiñones, 2006). Emerging research findings have indicated cultural influences in *computer mediated communication (CMC)* (e.g., Ess & Sudweeks, 2005), *computer supported cooperative work (CSCW)* (e.g., Setlock, Quinones, & Fussell, 2007), *online learning* and *asynchronous learning networks (ALN)* (e.g., Morse, 2003).

Integrating these four lines of empirical research into a conceptual framework of culture, cognition and computers, this research puts forward the basic premise that social affordances of technology vary across cultures. The challenge for technological learning environments is that interacting through technology is sometimes problematic. First, it makes interaction more difficult (Clark & Brennan, 1991; Olson & Olson, 2002). Second, it may not mean, feel and afford the same thing to everyone. To repeat, social affordances of technology might vary across cultures. Designers might assume that the online environment is perceived similarly by everyone, but do culturally different users perceive different affordances? Recent empirical findings in cross-cultural psychology have indicated a marked difference between cultures in visual perception and thinking (Nisbett, 2003). If culture and cognition are not dissociated (Dimaggio, 1997; Nisbett & Norenzayan, 2002; Ross, 2004), then we might effectively question the "what

you see is what I see (WYSIWIS)” paradigm for designing collaborative learning applications.

The collaborative learning paradigm is grounded in social constructivist epistemology, with some researchers adhering to a radically dialogical epistemology of intersubjective learning (see Suthers, 2006, for a discussion of different epistemologies in CSCL). CSCL emphasizes social interaction and in the era of globalization, social interaction is often intercultural. Research into social aspects of Human Computer Interaction (HCI) has shown that even computer-literate users tend to use social rules and display social behavior in their interactions with computers (Reeves & Nass, 1996). Social behavior is strongly grounded in culture as every person carries within himself/herself patterns of thinking, feeling and potential acting. To learn new patterns of thinking, feeling and acting one has to unlearn old patterns, a more difficult task than learning them in the first place (Hofstede, 1997).

1.3. *Research objectives*

Setting the thematic agenda for CSCL for the next decade, Suthers (2006) identifies “intersubjective meaning making” as the central concern of CSCL. Suthers calls for an eclectic approach integrating “experimental, descriptive and design methodologies” to investigate technology affordances supporting intersubjective meaning making (IMM). IMM is inherently intercultural in a multicultural classroom and whenever a collaborative group is composed of members from different cultures. If intercultural communication between group members becomes an issue of concern, then Dewey’s “problematic situation” can become doubly problematic. More specifically, it is not just the object of a learner’s inquiry that becomes problematic, but also the very intersubjective acts seeking to engage in joint inquiry. On a secondary level, cultural issues in CSCL environments have not been systematically explored. In CSCL and ALN environments involving intercultural interactions, the lack of understanding of culture’s role can render the design of technology problematic. For effective learning technology design, issues of intercultural collaboration must be given adequate consideration at the interface, interaction and instruction levels. The lacuna in understanding the role of culture in CSCL is the secondary research problem addressed by this research project.

This research’s particular concern is to empirically investigate the extent to which culture influences how participants in intra- and inter-cultural computer supported collaborative learning environments (a) appropriate affordances, (b) perceive themselves and their collaborative others, and (c) subsequently perform on individual learning outcomes assessments. This research is not merely about Human Computer Interaction (HCI) — i.e. interacting with technology — it is also about technological intersubjectivity (TI) — i.e. interacting with people.

1.4. Research questions

The two research questions below are informed by a discussion of Hofstede's cultural dimensions model (1997), a review of cultural differences in traditional learning settings (Hofstede, 1986), a discussion of Edward Hall's communicative context dimension (Hall, 1977), a review of Nisbett and colleagues' empirical findings concerning culture and cognition (Nisbett & Norenzayan, 2002), and by a comprehensive reading of the impact of cultural differences in human computer interaction.

R1. To what extent does culture influence participants' appropriation of affordances in a CSCL environment?

R2. To what extent does culture influence technological intersubjectivity in a CSCL environment?

Any medium of interaction provides a set of potentials for action. However, it is up to the actors to decide which potentials are taken up, and for what purposes. Culture may influence these decisions. Furthermore, the meanings of actions in a technology mediated environment are interactionally negotiated. Culture may also influence such a negotiation. Therefore, the unit of analysis for R1 is the individual interactional act. The levels of analysis are culture, gender, dyadic culture, and dyadic gender. Given the gender differences in interaction (Tannen, 1996), gender and dyadic gender levels of analysis are used for disambiguating of results.

R1 investigates the extent to which the participants' cultural background influences their appropriation of affordances in a CSCL environment. R1 is informed by the ecological psychology notion of affordances (Gibson, 1979). R1 evaluates the influence of culture on the appropriation of affordances by studying dyadic interactions in intra- and inter-cultural CSCL settings. R1 is also informed by the relevant literature in cognitive psychology and cultural psychology summarized and critiqued in Section 2.3. R1 draws upon the nature of internal representations and external representations for distributed problem solving (Zhang, 1997, 1998; Zhang & Norman, 1994). The Gibsonian notion of affordance is evaluated in the light of recent experimental results demonstrating cross-cultural differences in cognitive and perceptual processes (Nisbett, 2003).

R2 investigates the extent to which the participants' cultural background influences technological intersubjectivity in a CSCL environment. R2 is grounded in the philosophical notion of intersubjectivity. R2 evaluates the influence of culture on technological intersubjectivity by studying dyadic interactions and mutual perceptions in intra- and inter-cultural CSCL settings. R2 is informed by Salomon's (1998) distinction between cultural effects with technology (during interaction) and effects of technology (after interaction). The extent to which culture influences technological intersubjectivity during interaction is informed by the concepts of discourse presence in online learning environments. The theoretical framework section on technological intersubjectivity discusses the notions of social presence (Rourke, Anderson, Garrison, & Archer, 2001), cognitive presence (Garrison, Anderson, & Archer, 2001), and teaching presence (Anderson, Rourke, Garrison, & Archer, 2001). The

coding schemes of presence in online learning environments were used to evaluate technological intersubjectivity during interaction. The unit of analysis for the first aspect of R2 (during interaction), is the discourse message. The levels of analysis are the culture, gender, dyadic culture, and dyadic gender. Again, given the gender differences in interaction (Tannen, 1996), gender and dyadic gender levels of analysis are used for disambiguation of results.

The second aspect of R2 (after interaction) evaluates the extent to which culture influences how a particular participant perceives the collaborative other after interaction. This second aspect of R2 is informed by Allport's contact hypothesis (1954). The contact hypothesis is considered one of the most important findings of social psychology (Amichai-Hamburger & McKenna, 2004; citing Brown, 2000). The contact hypothesis states that when the preconditions of equal status, superordinate goal and institutional support are met, contact between different groups will create a productive inter-group encounter and lead to positive inter-group relationships (Brislin, 1981).

In the pre-investigative session, participants rate themselves on the Portrait Values Questionnaire (PVQ) (Schwartz *et al.*, 2001). In the post-investigative session, participants rate their collaborative partners. This bi-directional assessment allows a comparison of participants' self-perception of individual values along with the perception of the individual values of their collaborative partners. The unit of analysis for the second aspect of R2 is the individual participant's difference in self-assessment and collaborative other-assessment on the PVQ instrument.

1.5. Related work on cultures, computers, and learning

Amant (2002) put forward a set of classroom exercises to provide what the author terms "international online interactions (IOI)". The exercises are categorized into unidirectional and bidirectional depending whether students interact with online artifacts or online individuals. Overall, the aim is to enhance intercultural competence and increase international awareness besides improving technical communication skills.

Kim and Bonk (2002) report cross-cultural differences in online collaborative behaviors of the US, Finnish and Korean participants in their study. Daniels, Berglund and Petre (1999) found cultural differences in international projects in undergraduate computer science education. McLoughlin (1999) based on her experiences with developing web-based instruction for Australian Indigenous education calls for a culturally responsive technology. Iivonen, Sonnenwald, Parma, and Poole-Kober (1998) found culturally influenced differences in language and communication styles in a library and information studies course taught over the Internet in Finland and US.

Walton and Vukovic's (2003) work with south African students from disadvantaged backgrounds found that differences in cultural specificity of visual forms and knowledge categorization make it difficult for the students to make the transition to

the web use Crump (2004) explored the effects of computing learning environment on the newly arriving international students at universities in New Zealand. Crump reports that the cooperative and collaborative learning environment was an issue of concern to the students. Crump says it is likely due to the oversimplification of social structure of groups, individual and group goals and the diverse nature of knowledge construction in the collaborative learning environments.

Duncker (2002) conducted an ethnography of the usability of a library metaphor used in digital libraries in the cultural context of the Maori, who are the indigenous population of New Zealand. Duncker says that metaphors and metaphorical thinking are strongly rooted in culture. The Maori found the digital libraries interesting but difficult to use due to the breakdown of the library metaphor given that Maori culture traditionally transferred knowledge as oral histories, songs, dances, and artifacts. Keller, Pérez-Quñones and Vatrappu (2006) outlined cultural issues and opportunities in computer science education.

Reviewing the body of recent research literature on online learning, Dabbagh and Bannan-Ritland (2005) identified the main themes of past research as: (1) mode of communication (asynchronous communication tools like email and synchronous communication tools like chat), (2) emerging research on interactivity, (3) online communities research spawned by the influential work of Rheingold (1994), (4) media and content research into hypertext and hypermedia, (5) research into web-based instruction and (6) research into student and instructor perceptions and perspectives on online learning. Overall, Dabbagh and Bannan-Ritland (2005, pp. 70–71) say that “much of the research is descriptive of particular learning contexts rather than experimental.” Given the increased cultural diversity of online learning settings, we need to better understand the role of culture in online learning environments. The experimental study reported in this paper addresses the above lacunae in the existing body of empirical evidence.

This research project empirically investigated how culture influences interactions in a quasi-asynchronous computer supported collaborative learning setting. Empirical observation and demonstration of the cultural influences in socio-technical environments is the critical first step in understanding the situated interactional practices in online environments. Systematic studies can then be conducted to formulate and evaluate guidelines and techniques for the design and implementation of online learning environments that take cultural considerations into account.

2. Methodology

Figure 1 below presents the conceptual and methodological framework of this research program. This conceptual framework allows for rigorous empirical inquiry of the phenomena in intra- and intercultural online environments. The semantic explanation of the schematic follows below.

Culture is conceptualized in this research as a cognitive schema (Sternberg, 2006). Therefore culture as a cognitive schema is treated as an antecedent to learning

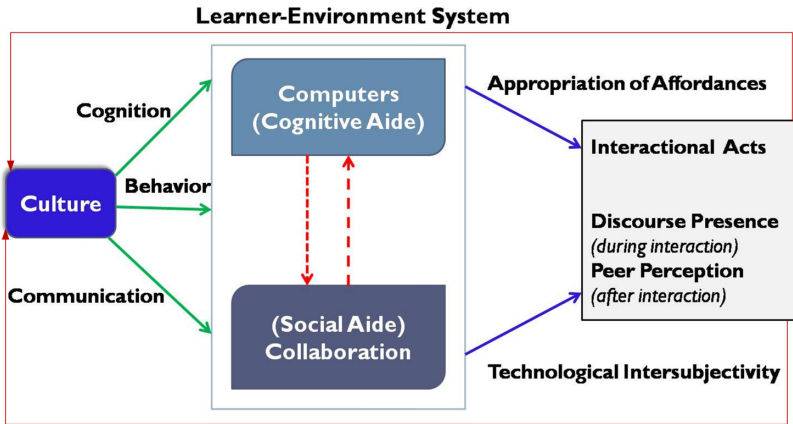


Figure 1. Conceptual and methodological framework.

interactions. Cultural schemas and cultural models are what human beings bring to an interactional situation. Cultural schemas and cultural models are adaptive structures. Therefore they are not rigid causal determinants of human behavior. However, they can be strong influencers of human behavior in appropriate situations and acceptable contexts. Culture as conceptualized in the schematic is an abstract antecedent that denotes the ways of thinking, acting, saying, behaving and believing that participants bring to any interaction. Participants bring biographical memorial capabilities to an interaction. This cognitive sense of culture as an antecedent to social interaction is identical to the social phenomenologist Alfred Schuetz's (1945, 1953) notion of "biographically determined situations". The arrows in the schematic are not causal determinants but they are causal influencers.

Human beings are social animals. We transform our material ecology first and that results in a social world (Marx, 2002/1845). Culture as an antecedent influences cognition (Nisbett & Norenzayan, 2002), behavior (Hofstede, 1997) and communication (Hall, 1977). Human beings, in the immortal words of the French existentialist philosopher Jean Paul Sartre, are "condemned to be free." Human behavior is not determined without an interactional situation. Further, according to the symbolic interactionism (Blumer, 1969), social interaction is characterized by the intertwining processes of self-indication and interpretation. A cultural schema requires a concrete situation to be activated and to be realized as external behavior.

The interaction between collaborative learning as social aid and computer tools as cognitive aid has been the foundational emphasis of the "representational guidance" research program pioneered by Suthers (2001) and implemented by Suthers and colleagues (Suthers & Hundhausen, 2003; Suthers, Vatrapsu, Medina, Joseph & Dwyer, 2007, 2008). This research project builds upon that body of work and begins a research program that takes as its starting point "technology affordances for intersubjective meaning making" (Suthers, 2006). In short, the experimental study

software enables a socio-technical environment with socio-technical affordances for collaborative learning. In online environments, human beings are actors in a technological environment (Allen, Otto, & Hoffman, 2004).

An affordance (Gibson, 1979) is the relational property between an actor and his/her environment (cognitive side). Technological intersubjectivity is the relational property between the actor and the other actor (social side). Since culture influences cognition, communication and behavior, it is predicted that in this socio-technical environment, culture influences both affordances and intersubjectivity.

This research conceptualized the cultural influence (as a cognitive schema) on affordance as “appropriation of affordances” and operationalizes it as an empirically observable external record of interactional acts. This was investigated by the experimental method to be discussed shortly. Informed by culture theory and cultural psychology findings several *a priori* hypotheses were empirically tested.

This research conceptualized the cultural influence on intersubjectivity in technology mediated environments as “technological intersubjectivity” and operationalizes it as an empirically observable external record of discourse presence during interaction and peer perception after interaction. This was also investigated by the experimental method to be discussed shortly. Informed by culture theory and cultural psychology findings several *a priori* hypotheses were empirically tested.

In sum, Figure 1 is the crux of the ontological, epistemological and methodological arguments of this research project.

2.1. Method

To empirically evaluate the basic premise of this research project that socio-technical affordances vary across cultural dimensions, an experimental study was designed and conducted. The experimental study kept invariant the technological interface and interactional setting and varied the cultural backgrounds of the participants. Briefly, the experimental study investigated how pairs of participants from similar and different cultures (Chinese-Chinese, Chinese-American, and American-American) appropriated socio-technical affordances and forged technological intersubjectivity in a quasi-asynchronous computer supported collaborative learning environment in order to solve a public health science problem. The experimental study’s analytical focus was on appropriation of affordances (cognitive processes) and on technological intersubjectivity (social behavior) and on how these influenced individual learning outcomes. The experimental study builds on the methodological paradigm for the study of asynchronous collaborative learning developed by Suthers, Vatrappu, Medina Joseph and Dwyer (2008).

In all three conditions, the collaborative dyads were given the same experimental task. All the dyads interacted in the same software environment after reading the same instructions, software tutorial and demonstration. The same instruments were administered to all participants. Construct validity was addressed by using existing instruments with high validity and reliability (Bhawuk & Brislin, 1992; House *et al.*,

Table 1. Experimental study design.

Dyad's Cultural Profile	Pre-Investigation	Investigative Session	Post-Investigation
Chinese	1. Informed Consent		
Chinese	2. GPA/GRE Release Instruments	8. Collaborative Problem-Solving	
Anglo-American	3. Demographic		9. Individual Essay-Writing Instruments
Anglo-American	4. Self-PVQ		10. Other-PVQ
	5. GLOBE		11. SL-ASIA/ICSI
	6. Study Instructions		12. QUIIS
Anglo-American	7. Software Tutorial		
Chinese			

2004; QUIIS, n.d; Schwartz *et al.*, 2001; Suinn, Ahuna, & Khoo, 1992). The space and time characteristics of the experiment were also held as identical as possible with all the participants performing the experiment in the same laboratory with the same configuration on the same machines with all sessions scheduled between 9 AM–8:30 PM. Table 1 above presents the experimental design.

Participant dyads were presented materials related to a complex public health problem. The experimental study task materials were presented as a trail of information. This trail of information consisted of field observations, lab studies, hypotheses, opinions and background information. Participants explored this trail of information through a built-in web browser of the experimental software. Participants used the interface for constructing graphical “knowledge map” representations customized for the purpose of recording hypotheses, data, and evidential relationships between them. The treatment consisted of the cultural profile of the collaborative dyad (intercultural vs. intracultural) interactively doing problem solving in an asynchronous collaboration mode. All the participants were provided with identical study instructions and software tutorial.

2.1.1. Software

The computer supported collaborative learning environment used in this experimental study has an “information viewer” on the left in which materials relevant to the problem are displayed. This information viewer functions as a simple web browser, but the presentation of materials is constrained as discussed in the next section. The environment has a shared workspace or “information organizer” on the right-hand side in which participants can share and organize information they gather from the problem materials as well as their own interpretations and other ideas. The “discussion” tool below the “information viewer” on the left enables participants to discuss their ideas in a threaded discussion format. Figure 2 below displays a captioned screenshot of the environment used in the experimental study.

The “information organizer” workspace includes tools derived from Belvedere (Suthers, Weiner, Connelly, & Paolucci, 1995; Toth, Suthers, & Lesgold, 2002) for constructing knowledge objects under a simple typology relevant to the experimental task of identifying the cause of a phenomenon (e.g. a disease), including data (green rectangles, for empirical information) and hypotheses (pink rectangles, for postulated causes or other ideas). There are also linking tools for constructing consistency (“for”) and inconsistency (“against”) relations between other objects, visualized as green links labeled “+” and red links labeled “-” respectively. “Unspecified” objects and “unknown” links are also provided for flexibility. Finally, an embedded note object supports a simple linear (unthreaded) discussion that appears similar to a chat tool; except that a note is interactionally asynchronous and one can embed multiple notes in the knowledge map and link them like any other object (see Figure 2).

In the “threaded discussion” section of the environment (see Figure 2) participants can embed references to knowledge map objects in the threaded discussion messages by selecting the relevant one or more graph object while composing the message. The references show up as small icons in the message. When the reader selects the icon, the corresponding object in the knowledge map is highlighted, indicating the intended referent. Mutual awareness of participants’ artifacts is supported in the software environment as follows: all knowledge map nodes and threaded discussion messages carry the name of the participant who first created it. These mutual awareness features of artifacts and of activity are shown in Figure 2, a screenshot taken from I3P1 (I stands for Anglo-American–Chinese inter-cultural session, 3 stands for the number of experimental session in this condition, P1 stands for Participant 1).

In Figure 2, the I3P1’s screen name of “Teri” (screen name selected by participant) appears on the title bar of the application window and on knowledge map nodes and message created by I3P1. Similarly, I3P2’s screen name of “Ben” appears on artifacts created by him. Artifacts marked with a solid red triangle in the top right corner are from I3P2 and are yet to be opened by I3P1. The yellow circle on the threaded discussion message of I3P1 in the lower left region of Figure 5 indicates artifacts created by “Teri” (I3P1) but not yet read by the study partner, “Ben” (I3P2). Thus, each participant is aware of the new artifacts from the study partner as well as the artifacts not yet read by their study partner. In the lower-left corner of Figure 2 shows I3P1 appropriating the affordances for referencing knowledge map artifact (yellow outlined hypothesis node in the bottom-right of Figure 2).

2.1.1.1. *Protocol for workspace updates*

To simulate asynchronous online interactions, the actions of each participant in the shared workspace were not displayed immediately in the other participant’s workspace. As a person worked, the actions of that person were sent to the other participant’s client application, but were queued rather than displayed. Participants

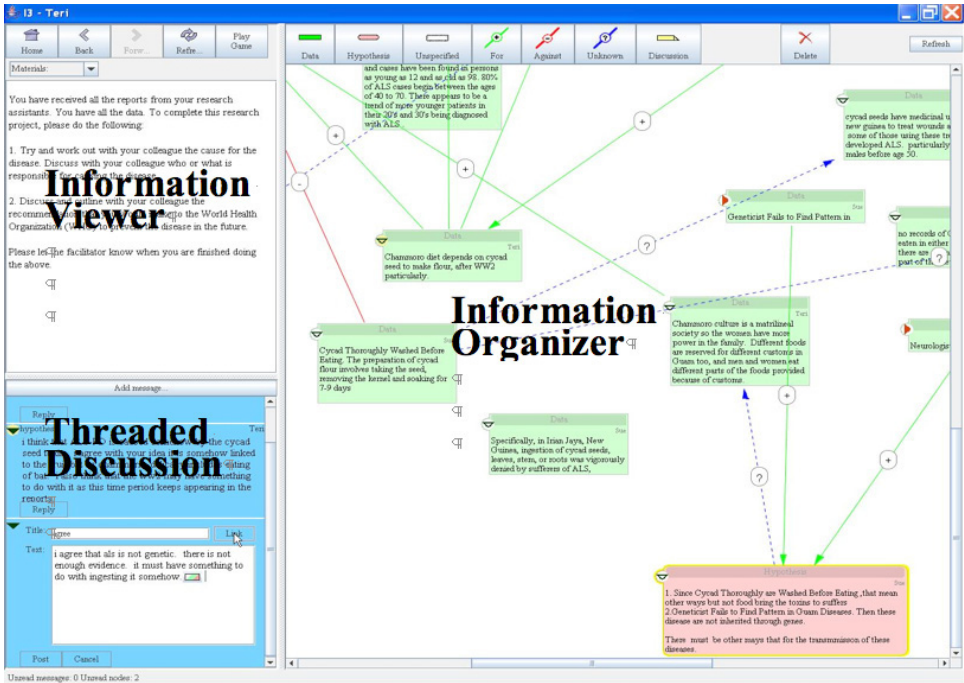


Figure 2. Screenshot from I3P1's session showing software features.

were given a new report (discussion forthcoming in 2.3) after playing the game of Tetris™. Tetris™ was chosen as it presents a different sensory-motor perceptual task than the primary experimental study task of collaborative knowledge map co-construction and simulates taking a break from the studies in real-worlds asynchronous learning settings (Suthers *et al.*, 2008). After the game of Tetris™, all of the currently queued actions on that client were displayed. Conflicts that might arise when both participants edited the same object were resolved through operational transformations (Sun, Jia, Zhang, & Yang, 1997). The delayed updating protocol simulates one aspect of the experience of asynchronous collaboration: a participant sees what one's partner has done upon returning to a workspace after a period of time. It excludes the possibility of synchronous conversation in which one participant posts a message in the workspace and receives an immediate reply. The "refresh" feature of the software enables one to get all updates to that point in time.

2.1.1.2. Alternates for action

The software environment provides multiple alternatives for the appropriation of affordances. For example, participants can discuss with each other using the threaded discussion tool or the embedded notes tool. Participants can also use the

knowledge-map objects to discuss the task at hand or any other topic of interest. Participants can refer to artifacts by deictic referencing (this, that, etc. . .) or use the cross-referencing feature of the threaded discussion.

Participants can externalize the perceived relations between their concepts by creating external evidential relations between objects in the knowledge-map, by spatial arrangement, or by mentioning them in discussion. Participants have multiple ways of sharing the information presented to them (threaded discussion, embedded notes, and knowledge-map). The research strategy was to provide participants with a feature rich collaborative environment with multiple alternates for action. By incorporating systematic variation in the assignment of participants to the collaborative dyad based on their cultural background and gender, the experimental design measured and observed systemic differences in how participants used the tools and resources of the technology (research question 1, appropriation of affordances) and related to each other during and after their interaction (research question 2, technological intersubjectivity).

2.1.2. *Materials*

2.1.2.1. *Topics*

The study presented participants with a “science challenge” problem that requires participants to identify the cause of a disease known as ALS-PD on the island of Guam. This disease has been under investigation for over 60 years, in part because it shares symptoms with Alzheimer’s and Parkinson’s diseases (Lieberman, 2004). Only recently have investigators converged on both a plausible disease agent (a neurotoxic amino acid in the seed of the Cycad tree) and the vector for introduction of that agent into people (native Guamians’ consumption of fruit bats that eat the seed). Over the years, numerous diverse hypotheses have been proposed and an even greater diversity of evidence of varying types and quality explored. These facts along with the relative obscurity, multiple plausible hypotheses, contradicting information, ambiguous data and high interpretation make this a good experimental study task for measuring cultural effects on appropriation of affordances and on technological intersubjectivity. All participants began with a mission statement that provided the problem description and task information. Four mission statements corresponding to the four participant assignment configurations (Chinese vs. Anglo-American x P1 vs. P2) were administered accordingly.¹

2.1.2.2. *Distribution of information articles*

Source materials were provided in the form of short articles, typically consisting of two brief paragraphs and an image. Each article was designed to provide one key item of information relevant to the generation or evaluation of a hypothesis. The articles provided evidence both for and against three major hypotheses: genetic

¹The materials can be accessed at <http://lilt.ics.hawaii.edu/culturalreps/materials/>.

causes (G), consumption of cycad flour (C), and consumption of bats (B) and other general information about the disease and its demographics (D). The distribution of information across articles, participants and time are discussed in detail in Suthers, Vatrapsu, Medina Joseph and Dwyer (2008). Briefly, information needed to draw a conclusion about any given hypothesis was distributed across more than one article. The articles presented to a given participant were clustered into four reports each consisting of four articles. Each participant received a different sequence of articles. There was no overlap in the information distributed between the participants except for one background article. The study follows the “hidden profile” experimental paradigm in studies of group problem solving (Stasser & Stewart, 1992). Information was distributed across participants such that a participant relying only on information he or she directly received will come to a suboptimal conclusion. Because of this distribution of information, conclusions can be drawn concerning information sharing by eliciting participants’ beliefs and evidence for those beliefs at the end of the experimental session.

As mentioned earlier, participants were given information as 4 reports each with four articles. Information was not only distributed between the two participants but also sequentially organized within a session. After the four reports, the evidence is ambiguous for all hypotheses, but a combination of the cycad as a source of the toxin and bats as a vector for introduction of that toxin to humans resolves many of the ambiguities. This is due to fact that this hypothesis (Cycads as source of toxicity + Bats as vectors that transmit the disease) incorporates the well developed case for cycads while addressing the evidence against cycad flour toxicity.

Due to the distribution of conflicting evidence, sharing of information across participants and study sessions is needed to expose the weakness of genetics as well as to construct the more complex explanation involving bats and cycad seeds. Given the nature of the information distribution between the two participants, working out the consumption of bats as an optimal hypothesis involves making these cross-report collaborative connections and also considering and rejecting other probable factors.

The study task and task materials are designed to highlight “social division of cognitive labor” (Dimaggio, 1997). The experimental study encouraged participants to interact with each other by including the following reinforcing task instruction on each report (set of 4 articles): “Please share and discuss this information with you colleague. Please play the game to receive the next report from your research assistant.” The next section discusses several research hypotheses generated from the discussion of empirical findings in the theoretical framework section.

2.1.3. *Research hypotheses*

2.1.3.1. *Research question 1*

Research Hypothesis 1 (RH1): Chinese participants will appropriate more affordances to reference regions of the knowledge maps and groups of knowledge map

objects; Anglo-American participants on the other hand will appropriate more affordances to refer to individual objects.

The first hypothesis was generated based on the cultural difference in attention to field vs. object (Masuda & Nisbett, 2001). Masuda and Nisbett (2001), based on the results of their experimental manipulation of “focal” objects in perceptual fields have found that Japanese participants attended more to the perceptual field as a whole, On the other hand, American participants attended more to the “focal” objects. Masuda and Nisbett also report that Japanese participants tend to give more “contextual” descriptions of the scene whereas American participants usually refer to objects. Also, when the background was changed, the performance of Japanese participants on a recognition task decreased. On the other hand, there was no effect on American participants’ performance for the same experimental task.

This cultural difference is highly relevant to collaborative knowledge map learning environments. In a knowledge map environment, Chinese participants might pay attention to a group of interrelated knowledge map objects whereas Anglo-American learners might attend to individual objects and evidential relational links. The cultural difference in attention might vary the ways in which referencing and deixis are carried out in collaborative discourse.

Research Hypothesis 2 (RH2): Chinese participants will appropriate affordances to create a greater number of evidential relation links in the knowledge map compared to Anglo-American participants.

This hypothesis was generated from cultural difference in perception of objects vs. perception of relationships (Ji, Peng, & Nisbett, 2000; Masuda & Nisbett, 2006). East-Asian participants in experimental studies were found to perceive relationships between things more than Anglo-American participants in the same experiments (Nisbett & Norenzayan, 2002).

Based on the above empirical finding, it was predicted that Chinese participants might perceive more relationships between the information in knowledge map and instructional materials leading to a greater number of evidential relation links in the knowledge map.

Research Hypothesis 3 (RH3): Anglo-American participants will appropriate affordances to create more threaded discussion messages compared to Chinese participants.

This hypothesis with regard to research question R1 was made from the cultural difference of low-context vs. high-context communication (Hall, 1977) between Anglo-American participants and Chinese participants. Hall characterizes speaking as an art in high-context cultures, with an emphasis on the emotional aspect. High-context cultures privilege social motivation. In low-context cultures, by contrast, members expect to influence others to act by explicitly pointing out pertinent information. The information provided implicitly enables the communicating other to take the desirable decision. Low-context cultures privilege rational information.

In collaborative problem solving environments, the cultural communicative context of the learners might influence how much active discussion, elaboration and reflection they engage in.

Research Hypothesis 4 (RH4): Chinese participants will appropriate affordances to create more embedded discussion notes compared to Anglo-American participants.

This hypothesis with regard to research question R1 was also made from the cultural difference of low-context vs. high-context communication (Hall, 1977) between Anglo-American participants and Chinese participants discussed above.

Since the communicative context varies across cultures than it becomes a variable of interest in the participants' interactional accomplishment of problem solving.

2.1.3.2. *Research question 2*

Research Hypothesis 5 (RH5): Chinese participants will copy+paste from source materials more than Anglo-American to directly quote statements of scientific experts in the experimental materials.

This hypothesis was generated based on the GLOBE cultural dimension of power distance (House *et al.*, 2004). Power distance refers to "the degree to which members of an organization or society expect and agree that power should be stratified and concentrated at higher levels of an organization or government" (House *et al.*, 2004, p. 12).

Participants from the relatively high power distance Chinese culture might have higher respect for scientific authorities and experts. Therefore they might prefer to directly quote from the materials (arguments from authority). On the other hand, Anglo-American participants come from relatively lower power distance cultures. Hence, they might be more inclined to interpret/paraphrase the claims of scientific experts compared to direct quotation.

Research Hypothesis 6 (RH6): Anglo-American participants will make more individual contributions to the study partner than the Chinese participants.

This hypothesis was generated from the GLOBE cultural dimensions of in-group and institutional collectivism (House *et al.*, 2004). In-Group collectivism refers to "the degree to which organizational and societal institutional practices encourage and reward collective distribution of resources and collective action" (House *et al.*, 2004, p. 12). Institutional collectivism refers to "the degree to which organizational and societal institutional practices encourage and reward collective distribution of resources and collective action" (House *et al.*, 2004, p. 12).

Based on the cultural dimensions differences discussed above, variance was predicted in the degree to which a participant marks her/his individual contribution with one's own name (e.g. putting a name in the subject line of a message); or manipulate study partner's contributions; or invite the study partner to edit or otherwise manipulate one's contributions. Differences were also predicted between Chinese participants and Anglo-American participants in whether the study partner

is addressed as an individual or contributions are simply offered to the shared space rather than the person.

Research Hypothesis 7 (RH7): Chinese participants will make more collective contributions than Anglo-American participants.

This hypotheses was also generated from the GLOBE cultural dimensions (House *et al.*, 2004) of in-group and institutional collectivism (see discussion in RH6 above).

Research Hypothesis 8 (RH8): Chinese participants will have more social presence than the Anglo-American participants in the collaborative discourse.

This hypothesis was based on the GLOBE cultural dimensions of in-group and institutional collectivism (House *et al.*, 2004) and the concept of social presence (Rourke *et al.*, 2001) in the asynchronous learning networks literature. “Social presence is defined as the ability of learners to project themselves socially and affectively into a community of inquiry” (Rourke *et al.*, 2001, p. 2).

Since Chinese participants belong to a collectivistic culture, it was predicted that they would exhibit greater social projection in the collaborative discourse.

Research Hypothesis 9 (RH9): Anglo-American participants will have more cognitive presence than Chinese participants in the collaborative discourse.

This hypothesis was based on the GLOBE cultural dimensions of in-group and institutional collectivism (House *et al.*, 2004) and the concept of cognitive presence (Garrison *et al.*, 2001) in the asynchronous learning networks literature. “Cognitive presence is defined as the extent to which learners are able to construct and confirm meaning through sustained reflection and discourse in a critical community of inquiry” (Garrison *et al.*, 2001, p. 5).

Since Anglo-American participants belong to an individualistic culture, they might exhibit greater cognitive presence in the collaborative discourse.

Research Hypothesis 10 (RH10): Chinese participants will have more teaching presence than Anglo-American participants in the collaborative discourse.

This hypothesis was generated from the GLOBE cultural dimensions of in-group and institutional collectivism (House *et al.*, 2004) and the concept of teaching presence (Anderson *et al.*, 2001) in asynchronous learning networks. Teaching presence is the “the design, facilitation, and direction of cognitive and social processes for the purpose of realizing personally meaningful and educationally worthwhile learning outcomes” (Anderson *et al.*, 2001, p. 5).

Since Chinese participants belong to a collectivistic culture, they might exhibit greater teaching presence in the collaborative discourse.

Research Hypothesis 11 (RH11): Peer ratings will diverge from self ratings the most in the intercultural group compared to the intracultural groups.

The second aspect of research question R2 is operationalized as an empirical evaluation of the contact hypothesis (Allport, 1954). The contact hypothesis states that when the preconditions of equal status, superordinate goal and institutional support are met, contact between different groups will create a productive inter-group encounter and lead to positive inter-group relationships (Brislin, 1981). The

contact hypothesis is considered one the most important findings of social psychology (Amichai-Hamburger & McKenna, 2004; citing Brown, 2000).

Equal status was ensured to both participants by equal payment of US\$75 per person, equal social role in the experiment, and by recruiting from the same academic level (graduate students). The same superordinate goal of discovering the cause of a public health problem was provided to both of the participants. Participants not only make a World Health Organization (WHO) report but also are informed of an award of US\$200 for the best performing team. Institutional support was equally provided by giving the participants the same set of computer tools in the same laboratory.

In the pre-investigative session, each participant rated himself/herself on the Portrait Values Questionnaire (PVQ) (Schwartz *et al.*, 2001). In the post-investigative session, each participant rated their collaborative partner on the same scale (with modified instructions). This change in the directionality of assessment allows for an analysis of correlation between each participant's self-report of his/her own individual values and the report of the perceived individual values of the collaborative other.

This concludes the discussion of the set of research hypotheses generated based on the grounds of recent empirical findings. In the next section, selection and assignment of participants to the three conditions are discussed.

2.1.4. *Participants*

Participants were recruited from the graduate student community at the University of Hawaii at Manoa. Each participant was offered a payment of US\$75 for participating in the study. Participant selection and treatment assignment are discussed next.

2.1.4.1. *Sampling*

The concept of culture is taken in the cognitive sense of a "cultural schema" in this research project. However, "cultures do not talk to each other; individuals do" (Scollon & Wong-Scollon, 2001, p. 138) cited by Hewling (2005). Hewling (2005) rightly criticizes the tendency in cross-cultural computer mediated communication research to use cultural models bounded by modern nation-states. However, nationality based stratified sampling frames remain a methodologically convenient way to select participants provided. However, cultural homogeneity of the participants is not to be assumed but empirically measured. We used the PVQ individual values survey and the GLOBE instrument to empirically assess differences in the two participant groups at the individual and group levels.

The primary purpose of this experimental study is not to revalidate prior empirical findings on cultural differences but to inquire into the extent culture influences appropriation of socio-technical affordances and technological intersubjectivity in an experimental CSCL environment. It is towards that goal that validated instruments

were used for assessing cultural differences. Portrait Values Questionnaire (PVQ) (Schwartz *et al.*, 2001) was used to assess cultural values at the individual level. The GLOBE instrument (House *et al.*, 2004) was used to assess cultural dimensions at the group level.

2.1.4.2. *Selection*

Participants were contacted through in-class advertisements, email distribution lists and various on-campus bulletin boards. Chinese graduate students were solicited for participation in the study by contacting the student associations of P.R. China and R.O. China at the University of Hawaii at Manoa. The study promotional flyer and email requested potential participants to volunteer preliminary information by logging on to a website. This preliminary information proved useful in the scheduling of experimental sessions. Students from East-Asia and USA are directly enculturated into their national/ethnic cultures. Therefore, they can be considered representative samples of East-Asian and USA learner populations in a restricted sense. However, we measured the process of acculturation of Chinese participants by the validated instrument of SL-ASIA (Sunn *et al.*, 1992).

2.1.4.3. *Assignment*

Participants were randomly assigned to either the intra- or the inter-cultural profiles and the same or different gender profiles. Excluding 6 pilot studies, a total of 33 experimental sessions involving 66 pairs of participants were conducted. Data from 3 experimental sessions was discarded due to issues of a missing screen recording, a software crash and a disqualification. There were 10 pairs of participants for each of the three treatment groups: Chinese-Chinese intracultural; Anglo-American-Anglo-American intracultural, and Anglo-American-Chinese intercultural groups. All the three conditions were gender-balanced because gender can substantially influence social interaction (Tannen, 1996). Each treatment group included 3 female-female, 3 male-male and 4 female-male dyads.

2.2. *Instruments*

The different instruments used for the measurement of the constructs are listed below.

2.2.1. *Demographic questionnaire*

A demographic questionnaire (see Vatrappu, 2007, pp. 275–276) was administered to collect participants' familiarity with each other, with online learning environments, with usability evaluation studies as well as data about age, gender, ethnic background, duration of stay in the USA (for Chinese participants), duration of stay in the state of Hawaii (for all participants) and cumulative grade point average (CGPA). All participants were requested to make a self-report of their CGPA and

also assign a release form for obtaining official records of their CGPA, graduate record examination (GRE). Additionally, Chinese participants were requested to authorize a release of their test of English as a foreign language (TOEFL) scores.

2.2.2. *Self-perception: Portrait Value Questionnaire (PVQ)*

The 40 item version of the PVQ instrument (see Vatrapsu, 2007, pp. 277–279) recommended for intercultural contexts (Schwartz, S. H., personal communication) was used in the study. The PVQ scale measured cultural values at the individual level. Cronbach's "alpha measures of internal consistency range from .37 (tradition) to .79 (hedonism) for the PVQ (median, .55)" (Schwartz *et al.*, 2001, p. 532). Gender specific versions of the self perception PVQ scale were administered.

2.2.3. *GLOBE cultural dimensions instrument*

The GLOBE instrument (House *et al.*, 2004) was used to measure cultural values at the group level (see Vatrapsu, 2007, pp. 280–293). Sections 1 and 3 of the original GLOBE instrument were used in this study. Section 1 of the GLOBE instrument measures a responder's perceptions of their society ("Section 1 — The way things are in your society"). Section 3 of the GLOBE instrument measures a responder's preferences for their society ("Section 3 — The way things generally should be in your society").

According to the "Guidelines for the Use of GLOBE Culture and Leadership Scales",² "the construct validity of the culture scales was confirmed by examining the correlations between the GLOBE scales with independent sources (e.g., Hofstede's culture dimensions, Schwartz's value scales, World Values Survey, and unobtrusive measures)" (House *et al.*, 2004). Phrasing of "this country" has been changed to "my home society" to remove possible ambiguity for Chinese graduate students (who might rate Hawaii, USA instead of the society they grew up in).

2.2.4. *Individual essays*

At the end of their collaborative science problem solving, the immediate post-test consisted of each participant individually writing an essay. Identical essay writing instructions were provided to all participants. The instructions asked the participants to state the hypotheses they considered, and whether and how their hypotheses differed from those of their study partners' and their final conclusion.

2.2.5. *Peer-perception: Portrait Value Questionnaire (PVQ)*

Technological intersubjectivity has been operationalized as presence during interaction and perception of the other after interaction. The validated coding schemes

²www.thunderbird.edu/wwwfiles/sites/globe/pdf/GLOBE_Culture_and_Leadership_Scales_Guidelines.pdf.

for social presence (Rourke *et al.*, 2001), cognitive presence (Garrison *et al.*, 2001), and teaching presence (Anderson *et al.*, 2001) were used to measure technological intersubjectivity during interaction.

Technological intersubjectivity after interaction was measured by the second immediate post-investigative-test. This was the administration of the Portrait Value Questionnaire (PVQ) (Schwartz *et al.*, 2001) instrument with a reversal of the direction of assessment (see Vatrappu, 2007, pp. 304–306). This time instead of assessing themselves, participants assessed their collaborative partners. Based on their collaborative interactions, each participant rated his/her impressions of the study partner on the Portrait Value Questionnaire (PVQ).

2.2.6. *Acculturation: SL-ASIA questionnaire*

Acculturation is a process that occurs when two or more cultures interact together. Acculturation occurs as the majority host culture absorbs to a certain extent with the minority immigrant culture or because both the cultures co-exist (Suinn *et al.*, 1992). Close contact with a host culture can lead one to adopt some if not all of that host culture's values. In cross-cultural research, the user's perception of his/her identity is important, as it is a subjective statement of cultural character. Individuals from the minority immigrant culture with high acculturation may behave like the individuals from the majority host culture. This becomes an external variable in cross-cultural research. This external variable can be controlled by measuring the acculturation level of the participants belonging to the minority immigrant culture (Triandis, Kashima, Shimada, & Villareal, 1986). Participants with high level of acculturation can be best used as members of the majority host culture or not included in the study (Triandis *et al.*, 1986). This research project used the Suinn-Lew Asian Self Identity Acculturation (SL-ASIA) scale (Suinn *et al.*, 1992) to measure the acculturation levels of the Chinese participants (see Vatrappu, 2007, pp. 307–311). This scale was chosen as it is specifically designed for Asians. For a discussion of other acculturation scales, refer to Vatrappu (2002, pp. 14–16). Suinn *et al.*, (1992) reported an internal-consistency estimate of .91 for the SL-ASIA instrument.

2.2.7. *Intercultural sensitivity: Intercultural sensitivity instrument*

Intercultural sensitivity is a vital skill for intercultural collaborations (Bhawuk & Brislin, 1992). The SL-ASIA scale provided a measure of Chinese participants' assimilation to USA. The intercultural sensitivity instrument (ICSI) (Bhawuk & Brislin, 1992) was used to measure the Anglo-American participants' self-assessment of intercultural sensitivity (see Vatrappu, 2007, pp. 312–315). Bhawuk and Brislin (1992) report that “the ICSI was validated in conjunction with intercultural experts at the East-West Center with an international sample ($n = 93$)” (p. 423). The word “Japan” in the original ICSI scale was changed to “China” to fit the context of Chinese-American collaboration setting of the experiment. Part three of the original

ICSI instrument was not used, as pilot studies indicated that it was irrelevant to the purposes of this experimental study.

2.2.8. *User satisfaction: QUIS questionnaire*

The QUIS 7.0 questionnaire (Chin, Diehl, & Norman, 1988) was administered to collect the participants subjective perceptions and preferences of the learning environment (see Vatrapsu, 2007, pp. 316–321). The QUIS has high reliability (Cronbach's $\alpha = 0.95$) and high construct validity ($\alpha = 0.86$) (Chin *et al.*, 1988; Harper, Slaughter, & Norman, 2006). The QUIS instrument also measured participants' subjective satisfaction with the instructions and the software tutorial besides various systems measures.

2.3. *Procedure*

Two students participated in each session. The entire experimental session lasted about three and half hours on average. Informed consent was obtained from all participants for both the pilot studies and the experimental studies. After signing the informed consent forms, participants completed the demographic survey. After completing CGPA/GRE/TOEFL score release, Self-PVQ, and GLOBE instrument forms, participants were introduced to the software and structure of the experimental study through an identical set of instructions and demonstrations. Participants completed the pre-investigative instruments at their respective workstations in different rooms from each other. They were then brought together for the software demonstration done using an overhead projector. After the software demonstration, the two participants were led back to their respective workstations in two different rooms. They were then instructed to begin work on the study task; Guam ALS-PD. Participants were allowed up to 90 minutes to work through all of the information available for this problem. The update protocol described earlier was used during the experimental session to present and synchronize the workspaces of the two participants. The distribution of information between participants and the sequential organization of information within the investigative session were discussed in the materials section above.

At the conclusion of the investigative session, each participant was given up to 30 minutes to write an individual essay on the hypotheses that were considered, the evidence for and against these hypotheses, and the conclusion reached. The software environment remained available to each participant during the essay writing, but the participants were requested not to engage in any further communication. After each participant completed writing the individual essay, the Other-PVQ instrument, the SL-ASIA acculturation instrument (for Chinese participants only) or the ICSI intercultural sensitivity instrument (for Anglo-American participants only) and the QUIS usability questionnaire were administered. This concluded the experimental session. Debriefing included informal discussion about software usability and strategies used during the experimental session.

Table 2. Summary of study constructs, measuring instruments and evaluation methods.

Experiment Design	Construct	Research Question	Measuring Instrument	Method
Independent Variable	Individual Cultural Values	R1, R2	Self-PVQ	Quantitative
	Cultural Dimensions		GLOBE	Quantitative
	Acculturation		SL-ASIA	Quantitative
Dependent Variable	Appropriation of Affordances	R1	Interactional Acts Individual Essay	Quantitative Quantitative
Dependent Variable	Technological Intersubjectivity During Interaction (Presence)	R2	Social Presence Cognitive Presence Teaching Presence	Quantitative & Qualitative (Using Content Analysis)
Dependent Variable	Technological Intersubjectivity After Interaction	R2	Other-PVQ	Quantitative
Dependent Variable	Usability	R1, R2	QUIS	Quantitative & Qualitative
Dependent Variable	Individual Learning Outcomes	R1, R2	Individual Essays	Quantitative & Qualitative

Table 2 presents a summary of the various empirical study constructs, their respective measuring instruments and proposed evaluation methods.

3. Results

Results are organized under four sections. Demographics provide a brief description and interpretation of the data collected by the demographic questionnaire. Culture measures presents a summary of the data collected by the Self-Portrait Values Questionnaire, the GLOBE instrument, SL-ASIA acculturation instrument and the ICSI instrument and provides a brief interpretation of the findings. Hypotheses testing presents results from descriptive and inferential statistical methods used in testing of the hypotheses of the experimental study. User interface satisfaction measures presents results from the quantitative data collected by the QUIS instrument. Individual learning outcomes section presents the results of the outcome analysis of the essays individually written by the participants after their collaborative learning session.

3.1. Demographics

The average self-reported age of the participants was 28.20 years (Range = 22 to 45 years, $SD = 4.6$). Anglo-American participants' self-reported average age was 28.2 years (Range = 23 to 45 years, $SD = 5.0$). Chinese participants self-reported an average age of 28.3 years (Range = 22 to 38 years, $SD = 4.33$). No significant differences in age were observed at any of the culture (Chinese, Anglo-American),

gender (female, male), dyadic culture (Anglo-American — Anglo-American, Anglo-American — Chinese, Chinese — Chinese), and dyadic gender (Female — Female, Female — Male, Male — Male) levels of analysis.

As expected, on the time spent in the USA question, Anglo-American participants averaged significantly more than the Chinese participants ($F(1, 59) = 323.14$, $p < 0.0001$). No significant differences were observed on the time spent in the state of Hawaii, USA at any of the four levels of analysis (culture, gender, dyadic culture, and dyadic gender).

A Pearson Chi-squared test of participants' prior participation in usability studies with respect to dyadic culture was not significant. A Pearson Chi-squared test of participants' prior enrollment in asynchronous networked learning (ALN) courses with respect to dyadic culture was not significant. Of the thirty total experimental sessions, in five sessions, the five participant pairs reported knowing their study partner from before the experiment. Of these 5 participant pairs that knew each other, none of the participants in a dyad rated the other as a spouse or a significant other. All of those who knew the other study participant reported knowing their study partner by virtue of belonging to the same program or taking the same class.

3.2. Culture

In this section, results from culture measures at the individual level and at the group level are presented.

3.2.1. Portrait Values Questionnaire

Cultural variation at the individual level was assessed by participants' responses to the Self-Portrait Values Questionnaire. Data analysis was done in accordance with the PVQ IV coding key (see Vatrapsu, 2007, pp. 325–327). Table 3 presents a

Table 3. Summary of the Self-PVQ scores.

Self-PVQ Individual Value	Anglo-American Group Mean (SD)	Chinese Group Mean (SD)	ANOVA <i>F</i> -Statistic
Mean Rating	4.22(0.35)	4.41(0.52)	2.57
Conformity	-0.57(0.80)	-0.05(0.71)	7.71**
Tradition	-1.04(0.78)	-0.83(0.80)	1.13
Benevolence	0.72(0.53)	0.41(0.51)	5.60*
Universalism	0.79(0.47)	0.48(0.47)	6.66*
Self-Direction	0.96(0.58)	0.56(0.53)	7.48**
Stimulation	0.30(0.63)	-0.27(0.77)	10.02**
Hedonism	0.01(0.90)	-0.31(0.94)	1.8730
Achievement	0.01(0.94)	-0.03(0.79)	0.04
Power	-1.12(0.85)	-1.09(0.78)	0.03
Security	-0.52(0.63)	0.37(0.62)	30.76**

* $p < 0.05$; ** $p < 0.01$

summary of the results of the self-perception Portrait Values Questionnaire scores for the Chinese and Anglo-American participant groups.

At the level of culture, Conformity, Benevolence, Universalism, Self-Direction, Stimulation, and Security were significantly different. Chinese participants scored higher on Conformity and Security. Anglo-American participants scored higher on Benevolence, Universalism, Self-Direction, and Stimulation. Similarly, at the level of dyadic culture, Conformity, Universalism, Self-Direction, Stimulation, and Security were statistically significant. Chinese-Chinese intracultural group participants scored higher on Conformity and Security compared to the American-American intracultural group. On Universalism, Self-Direction, and Stimulation, American-American intracultural group participants scored higher than the other two groups. The PVQ findings of this experimental study are similar to Hofstede's (1997) empirical findings on the individualism vs. collectivism dimension.

Even though marginally significant differences at the gender level of analysis were observed for the PVQ construct of Tradition (female participants scored lower), Benevolence (female participants scored higher), results show no significant differences for any of the ten individual values at the gender level of analysis. Gender seems to be not a strong determinant of the PVQ individual values.

3.2.2. *GLOBE instrument*

The GLOBE instrument for cultural dimensions has two sections: In the first section, respondents self-report up on items measuring "AS IS" societal attributes where as in the second section, they self-report on items measuring "SHOULD BE" societal attributes. Responses are made on a 7-step rating scale. Certain questions in both sections are reverse coded. Data analysis was done in accordance with the GLOBE instrument coding key (see Vatrappu, 2007, pp. 350–351). Summary of the results from the GLOBE instrument at the culture level of analysis are presented in Table 4.

3.2.3. *Acculturation of Chinese participants*

The SL-ASIA instrument (Suinn *et al.*, 1992) was used to measure the acculturation of Chinese participants. The original SL-ASIA scale had 21 questions but questions 22–26 had been added to accommodate current theory that acculturation is not linear and uni-dimensional but multi-dimensional and orthogonal. However, the validity and reliability of the newly added questions has not been tested by the authors. So, although the SL-ASIA with 26 questions is used, participant ratings on only the first 21 questions only used for the analysis. For the first and original 21 questions, a total value is obtained by summing across the answers for all 21 items. The final acculturation score is then calculated by dividing the total value by 21. The range of scores can be from 1.00 (Low Acculturation) to 5.00 (High

Table 4. Summary of GLOBE results.

GLOBE Cultural Dimension	AS IS			SHOULD BE		
	Anglo-American Mean (SD)	Chinese Mean (SD)	ANOVA <i>F</i> -Statistic	Anglo-American Mean (SD)	Chinese Mean (SD)	ANOVA <i>F</i> -Statistic
Uncertainty Avoidance	4.06(0.89)	4.47(0.87)	3.36	3.51(0.88)	5.03(0.75)	49.65**
Power Distance	4.81(0.86)	5.08(1.04)	1.25	2.40(0.55)	2.59(0.81)	1.06
Institutional Collectivism	3.49(0.95)	5.03(0.91)	43.55**	3.99(0.61)	4.28(0.74)	2.55
In-Group Collectivism	3.76(0.67)	5.74(0.83)	102.43**	5.27(0.94)	4.93(1.19)	1.53
Gender Egalitarianism	3.46(0.78)	3.29(0.95)	0.59	5.38(0.90)	4.94(0.71)	4.89*
Assertiveness	5.11(0.85)	3.91(0.88)	28.57**	3.58(0.98)	4.11(1.00)	4.20*
Future Orientation	4.54(0.84)	4.89(1.16)	1.73	4.57(0.99)	5.49(0.90)	14.23*
Performance Orientation	4.60(0.73)	4.67(0.89)	0.10	6.06(0.62)	5.77(0.66)	2.99
Humane Orientation	4.24(0.79)	4.63(0.90)	3.13	5.93(0.73)	5.44(0.58)	7.90**

* $p < 0.05$; ** $p < 0.01$

Acculturation). Because of the nature of the multiple choices content, a low score reflects low acculturation, while a high score reflects high acculturation.

The average acculturation score was 2.09 (Range = 1.52 to 3.05, $SD = 0.30$). Of the thirty Chinese participants, only three participants had an acculturation score greater than 2.5. A one-way ANOVA of SL-ASIA acculturation scores with respect to gender was not significant. A Pearson product-moment correlation between time spent in the USA by the Chinese participants and their SL-ASIA acculturation scores was negative but not significant. Similarly, a Pearson product-moment correlation between time spent in Hawaii by the Chinese participants and their SL-ASIA acculturation scores was negative but not significant. The above results indicate that acculturation scores of the Chinese participants were not high; acculturation can be ruled out as an extraneous variable in this experimental study.

3.2.4. Intercultural sensitivity of Anglo-American participants

The intercultural sensitivity instrument (ICSI) (Bhawuk & Brislin, 1992) was used to measure the Anglo-American participants' self-assessment of intercultural sensitivity.

For the US section of the ICSI, individualism items are scored regularly on the 7 point scale as indicated by the participants. For the US section of the ICSI, collectivism items are reverse scored. For the China section of the ICSI, individualism items are reverse scored while the collectivism scores are regularly scored. The total scores from both sections were divided by 32 to give an average composite score. The average ICSI score of the Anglo-American participants was 4.4 (Range = 4.0

to 5.2, $SD = 0.30$). A one-way ANOVA of ICSI scores with respect to gender was not significant. A Pearson product-moment correlation between time spent in the USA by the Anglo-American participants and their ICSI scores was negative but not significant. Similarly, there was no significant Pearson product-moment correlation between time spent in Hawaii by the Anglo-American participants and their ICSI scores. From the results, since intercultural sensitivity of the Anglo-American participants was relatively high across the sample, it can be considered as a factor that explains the experimental results pertaining to the contact hypothesis.

3.3. Hypotheses testing

This section is organized as follows. First, a discussion of how the data analysis was done for each of the research hypotheses is presented. Then, a summary table of the results of hypotheses testing is presented.

3.3.1. Data preparation, and analysis for hypotheses testing

For RH1 about referencing, video analysis of the screen recordings of participant sessions was done to code for the three types of appropriation of affordances for referencing: Unit, Composite, and Region. Keyboard and mouse events were obtained from the screen recordings using the Morae ManagerTM (version 1.1) software. When a participant included just one knowledge map object during cross-referencing in the Threaded Discussion, the contribution was coded as Unit referencing. When a participant included more than one knowledge map objects during cross-referencing, the contribution was coded as Composite referencing. When a participant included more than one knowledge map objects by doing a multiple selection by using a rubber band gesture to select all knowledge map objects in the enclosed region, the contribution was coded as Region referencing.

For RH2 about evidential relations; RH3 about threaded discussion message; and RH4 about embedded discussion notes, counts for the respective appropriation of affordances were obtained from the software logs of participant sessions. Figure 3 below shows an example of evidential relation linking.

For RH5 on copy + paste, video analysis of the screen recordings of participant sessions was done to obtain the counts for the appropriation of affordances for copy/paste from source materials.

RH6 predicted cross-cultural variation in individual contributions while RH7 predicted cross-cultural variation in collective contributions. Counts for both individual contributions and collective contributions were obtained from the software logs of participant sessions. There are two components to this analysis: Evidential relation linking and discourse utterances. When participants create an evidential relation in the experimental study's CulturalReps software, they link two knowledge map objects. Self and Other refer to knowledge map objects that are created by a participant and by the study partner respectively.

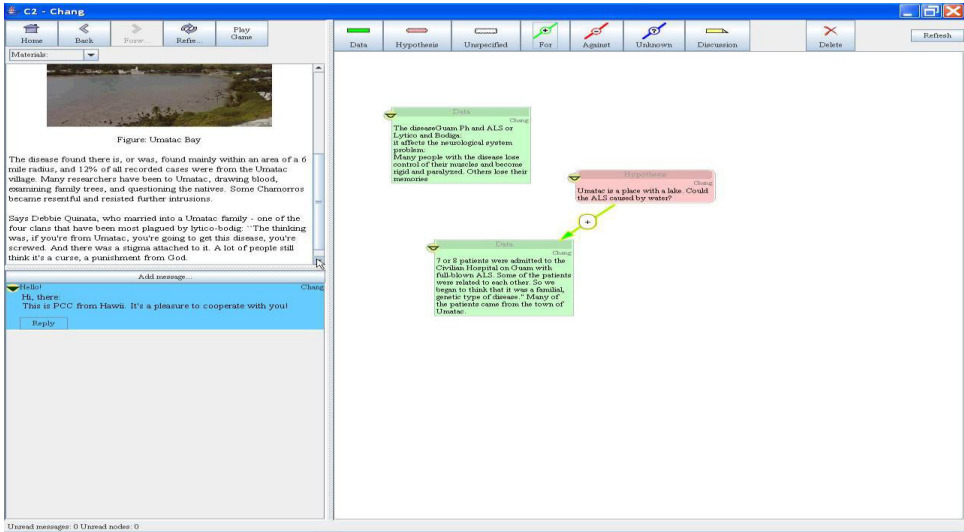


Figure 3. Individual/collective contributions: Evidential linking: screenshot from C2P2.

Depending on the source and destination of the knowledge map objects involved in a particular evidential relation link a typology was developed: Self-Self, Self-Other, Other-Self and Other-Other. Self-Self refers to evidential relation links between the participant’s own knowledge map objects. Self-Other refers to an evidential link between a participant’s own knowledge map object and that of the study partner, whereas with Other-Self this order is reversed. Other-Other refers to evidential relation links created by the participant between two knowledge map objects of the study partner. Individual links are the total number of Self-Self evidential relation links created by a participant. Collective links are the sum total of the Self-Other, Other-Self, and Other-Other relations made by the participant. Each participant’s textual discourse in threaded discussion and embedded notes were coded for personal and collective pronouns.

Individual attributions are utterances with “I”, “Me”, “My”, and “Mine”. Collective attributions are utterances that contained “You”, “Your”, “We”, “Our” and “Us”. Based on the above “coding and counting” scheme the number of individual contributions was obtained by the sum total of individual links and individual attributions. Similarly, the number of collective contributions was obtained by the sum of collective links and collective attributions.

RH8, RH9, and RH10 predicted cultural differences in technological intersubjectivity during interaction. Recall that technological intersubjectivity during in interaction was operationalized as discourse presence. Counts for technological intersubjectivity during interaction were obtained from a discourse analysis of the participants’ discussions.

The validated coding schemes for social presence (Rourke *et al.*, 2001), cognitive presence (Garrison *et al.*, 2001) and teaching presence (Anderson *et al.*, 2001) were used in the discourse analysis. Two coders were used for the discourse analysis. The agreement between two coders was calculated by Cohen's Kappa which showed high inter-coder reliability (Observed agreement = 0.91, Kappa = 0.83). Disagreements were resolved and then first coder performed discourse analysis of the entire corpus.

RH11 was based on Allport's contact hypothesis. This hypothesis was about technological intersubjectivity after interaction as measured by the other-perception PVQ instrument. Data analysis for the other-perception PVQ instrument was done in accordance with the PVQ IV coding key (Schwartz, personal communication). Note that Chinese participants in the intracultural experimental condition rated Chinese study partners whereas Chinese participants in the intercultural experimental condition rated Anglo-American study partners.

Similarly, Anglo-American participants in the intracultural experimental condition rated Anglo-American study partners whereas Anglo-American participants in the intercultural experimental condition rated Chinese study partners. For each participant a difference score was calculated between their Self-PVQ rating (a participant's rating of him/her-self) and the Other-PVQ rating (a participant's rating of the study partner). These difference scores were used in the data analysis to test RH11.

During the discourse analysis of the participant's discussion logs two interesting observations emerged. The first observation was that some participants explicitly discussed information sharing strategies and techniques at the start of the experimental sessions. The second observation was that some participants explicitly discussed knowledge map organization strategies and techniques. Based on Edward Hall's communication context cultural dimension (Hall, 1977) two *a posteriori* research hypotheses were made.

Research Hypothesis 12 (RH12): More Anglo-American participants will explicitly discuss information sharing strategies and techniques than Chinese participants.

Research Hypothesis 13 (RH13). More Anglo-American participants will explicitly discuss knowledge map organization strategies and techniques than Chinese participants.

For RH12 participants' logs were coded for explicit discussion of information sharing strategies and techniques. Similarly, for RH13 participants' logs were coded for explicit discussion of knowledge map organization strategies and techniques. Summary of the hypotheses testing results are presented in Table 5 below.

3.3.2. Summary of hypotheses testing results

3.4. User satisfaction measures

The QUIS 7.0 instrument also measured participants' subjective satisfaction with the instructions and the software tutorial besides various systems measures. For each participant, an average score was calculated for each of the six sections of the

Table 5. Summary of hypotheses testing results.

Research Hypothesis	Test-Statistic
RH1: Chinese participants will appropriate more affordances to reference regions of the knowledge maps and groups of knowledge map objects; Anglo-American participants on the other hand will appropriate more affordances to refer to individual objects.	$\chi^2(3, 60) = 6.30$
RH2: Chinese participants will appropriate affordances to create a greater number of evidential relation links in the knowledge map compared to Anglo-American participants.	$F(1, 56) = 5.542^*$
RH3: Anglo-American participants will appropriate affordances to create more threaded discussion messages compared to Chinese participants.	$F(1, 56) = 8.878^{**}$
RH4: Chinese participants will appropriate affordances to create more embedded discussion notes compared to Anglo-American participants.	$F(1, 56) = 1.727$
RH5: Chinese participants will copy+paste from source materials more than Anglo-American to directly quote statements of scientific experts in the experimental materials.	$F(1, 56) = 0.241$
RH6: Anglo-American participants will make more individual contributions to the study partner than the Chinese participants.	$F(1, 56) = 10.062^{**}$
RH7: Chinese participants will make more collective contributions than Anglo-American participants.	$F(1, 56) = 3.703$
RH8: Chinese participants will have more social presence than the Anglo-American participants in the collaborative discourse.	$F(1, 56) = 1.875$
RH9: Anglo-American participants will have more cognitive presence than Chinese participants in the collaborative discourse.	$F(1, 56) = 1.581$
RH10: Chinese participants will have more teaching presence than Anglo-American participants in the collaborative discourse.	$F(1, 56) = 1.594$
RH11: Peer ratings will diverge from self ratings the most in the intercultural group compared to the intracultural groups.	Failure to reject Contact Hypothesis
RH12: More Anglo-American participants will explicitly discuss information sharing strategies and techniques than Chinese participants	$\chi^2(1, 60) = 6.70^{**}$
RH13: More Anglo-American participants will explicitly discuss knowledge map organization strategies and techniques than Chinese participants.	$\chi^2(1, 60) = 7.18^{**}$

* $p < 0.05$; ** $p < 0.01$

QUIS instrument.³ These average scores were used in the data analysis. Table 6 presents summary results for the QUIS measures by culture.

No significant differences were found in participants' subjective ratings for the QUIS sections of Learning, System Capabilities and Tutorial at any of the four levels of analysis. On average, compared to the Chinese participants, Anglo-American participants gave higher ratings to the information display on the Screen and Terminology and System Information. However, on average, compared to the Chinese participants, the Anglo-American participants gave lesser overall reaction ratings. Experimenter bias and "demand characteristics" (Orne, 2002) can also ruled out

³The coding key for the QUIS instrument located at <http://lap.umd.edu/QUIS/QuantQUIS.htm> was used for data analysis.

Table 6. Summary of QUIS ratings by culture.

QUIS Construct	Anglo-American Mean (SD)	Chinese Mean (SD)	ANOVA <i>F</i> -Statistic
Overall Reaction	6.18(1.35)	6.49(1.22)	0.84
Screen	6.95(1.06)	6.15(1.19)	8.00*
Terminology & System Information	7.46(1.02)	6.81(1.22)	4.84*
Learning	7.78(1.09)	7.22(1.32)	3.17
System Capabilities	7.17(1.13)	6.85(1.43)	0.92
Tutorial	7.90(1.03)	7.71(1.03)	0.49

* $p < 0.05$

as results presented in Table 10 for the Tutorial measure of the QUIS instrument showed no significant differences for participants' subjective evaluation of the software demo and experimental instructions at any of the four levels of analysis.

3.5. Individual learning outcomes: Analysis of individually written essays

Each participant wrote an individual essay at the end of their dyadic collaboration. The software environment was available for the participants during the essay writing process. As discussed under the topics subsection of the materials section, the Guam ALS-PD public health problem materials presented to the participants contained multiple plausible hypotheses and that information was distributed between the participants as well sequentially organized. To reach an optimum solution to the public health problem, participants had to not only share their information but also to integrate it with that of their study partner's. Essay writing instructions are presented in Table 7.

Table 7. Individual essay writing instructions.

Written Essay Instructions.

Now that you have completed your exploration of the Guam Science Challenge Problem, please write a short essay that summarizes your findings. Please structure your essay as a report to the World Health Organization as follows:

1. Write a brief paragraph describing the hypotheses you considered, and summarize the evidence for and against them.
2. Write a paragraph on how your hypotheses varied from your study partner's hypotheses.
3. Write a paragraph comparing your conclusions to your study partner's conclusion and discuss how you worked together. If you agree, discuss how you came to agreement. If you disagree, discuss how you tried to convince your partner.

You will type in your essay into a word processor, using the document that has already been set up for you. You can access the software learning environment but please do not communicate with your study partner.

As you write your essay, please keep the following three points in mind:

- We will evaluate your essay based on its content; you don't need to worry about spelling or formatting.
- Remember to save your document frequently.
- You have up to 30 minutes to write your essay.

For the individual learning outcomes analysis of the essays, two coders analyzed the essays for (1) number of hypotheses mentioned by each participant, (2) participant's perception of study partner's divergence on final conclusion, (3) overall agreement between the two participants on final conclusion, and (4) Latent Semantic Analysis (LSA) of pair agreement of the individually written essays of the two participants of the collaborative session. The two coders analyzed essays from six sessions (2 sessions were selected from each of the three experimental conditions: American-American, Chinese-American, and Chinese-Chinese). Intercoder reliability measures were estimated on these initial coding (6 coded sessions = 20% of 30 total sessions) discrepancies were corrected, and the second coder then coded the rest of the sessions.

3.5.1. *Individual essays: Number of hypotheses mentioned by each participant*

This analysis relates to item #1 of the essay writing instructions (See Table 7). For this analysis each coder, counted the number of hypotheses mentioned in the essays. Since this was a simple count of the number of hypotheses explicitly mentioned in each essay, both the coders agreed on the number of hypotheses mentioned. A two-way analysis of variance with respect to culture did not yield significant main effect for culture or gender.

3.5.2. *Individual essays: Participant's perception of study partner's divergence on hypotheses*

This analysis relates to item #2 of the essay writing instructions (See Table 7). For this analysis, we analyzed the essays for the participants' subjective assessments on how their hypotheses differed from their study partners. A coding scheme of 5 categories of divergence was created (1 = very different, 2 = different, 3 = slightly different, 4 = similar, 5 = very similar) for assessing participants' comparisons to their study partners' hypotheses. The interrater reliability for this analysis was high ($Kappa\ statistic = 0.87$, 2-tailed $p < 0.0001$). A Kruskal-Wallis test of perception participant's perception of study partner's divergence on hypotheses was not significant with respect to culture. Similarly, a Kruskal-Wallis test of study partner's hypotheses divergence was also not significant with respect to gender.

3.5.3. *Individual essays: Overall agreement between the two participants*

This analysis relates to item #3 of the essay writing instructions (See Table 7). For this analysis, we analyzed the essays for the participants' subjective assessments on how they came to agreement or disagreement with their study partners. A coding scheme of 4 categories of agreement was created (1 = no agreement, 2 = partial agreement, 3 = substantial agreement, 4 = complete agreement) for assessing participants' statements about agreement/disagreement with their study partner on the final conclusion. The interrater reliability for this analysis was moderate

(*Kappa statistic* = 0.63, *2-tailed p* = 0.0001). A Kruskal-Wallis test of overall agreement was not significant with respect to culture. Similarly, a Kruskal-Wallis test of overall agreement was also not significant with respect to gender.

3.5.4. *Individual essays: Latent semantic analysis of pair agreement in essays*

Latent semantic analysis (Landauer & Dumais, 1997; Landauer, Foltz, & Laham, 1998) was done on the two individually written essays of a collaborative learning session. Specifically, pair-wise comparison each of the two essays of the 30 experimental sessions was conducted within the topic space of CSCL with 300 factors.⁴ Thus, we obtained 30 pair-wise agreement values for the 60 essays. A one-way analysis of variance of the LSA pair-wise agreement values with respect to dyadic culture (American-American, American-Chinese, Chinese-Chinese) was not significant. Similarly, a one-way analysis of variance of the LSA pair-wise agreement values with respect to dyadic gender (Female-Female, Female-Male, Male-Male) was not significant.

4. Discussion

4.1. *Summary of findings*

The primary objective of the experimental study was to investigate how culture influenced (a) the appropriation of affordances and (b) technological intersubjectivity both during and after computer supported collaboration. Towards that end, drawing from culture theory several theoretical predictions were made. Overall, as theoretically predicted, on average, Anglo-American participants made significantly more individual contributions, were more likely to explicitly discuss information sharing strategies or techniques, and were also more likely to explicitly discuss knowledge organization strategies or technique. Significant differences empirically observed for evidential relation linking was in the opposite direction from the theoretical prediction (Anglo-American participants of the experimental study created more evidential relation links compared to the Chinese participants contrary to the theoretical prediction made in research hypothesis 2). Even though theoretical predictions for linked referencing, embedded discussion, copy+paste of scientists' quotes, social presence, and cognitive presence were not supported by the presence of statistically significant differences, the observed empirical trends were all in the direction of theoretical predictions (Chinese participants created more embedded messages, and had more social presence in the collaborative discourse whereas American participants had higher cognitive presence in the collaborative discourse). However, for collective contributions and teaching presence the observed empirical trend was opposite to the theoretical predictions made. For a detailed substantial discussion of the results of statistical inferential testing of these theoretical

⁴<http://lsa.colorado.edu/cgi-bin/LSA-pairwise.html>.

predictions, refer to (Vatrapsu, 2007, pp. 222–265). Next, results from the learning outcomes analysis of the individually written essays are discussed in light of the interactional process analysis of the hypotheses testing.

Despite differences between the two cultural groups on (a) how they used the tools and resources of the learning environment and (b) how they related to each other during and after their collaborative learning interactions, individual learning outcomes analysis of the essays indicated no significant differences. Put differently, interactional process differences during the collaborative problem solving session on how participants (a) used the tools and resources of the learning environments and (b) related to each other are not accompanied by learning outcome product differences in the individually written essays. Recall that the software design included multiple alternates for interaction. Participants interacted through an asynchronous computer interface providing multiple tools for interaction (diagrammatic workspace, embedded notes, threaded discussion). One interpretation of the individual learning outcomes results is that participants utilized the “alternates for action” incorporated into the learning environment effectively and appropriately from their own cultural standpoints. For example, Anglo-American participants created more evidential relation links, made more individual contributions and were more likely to explicitly discuss information sharing and knowledge organization strategies than their Chinese counterparts. However, as mentioned earlier there are no individual learning outcome differences on the essays. Information sharing is necessary for joint problem solving in an asynchronous learning environment but it might be insufficient to account for learning outcomes (Suthers, Medina, Vatrapsu, & Dwyer, 2007). The results of the experimental study hint at the existence of multiple interactional pathways to learning outcomes in intra- and inter-cultural computer supported collaborative learning. However, more systematic empirical work is needed to (a) establish the existence of and (b) evaluate the efficacy of multiple cultural interactional pathways.

4.2. Cultural considerations in technology enhanced learning

Given the cross-cultural issues in the and Asia-Pacific area-specific challenges of online learning (Bhattacharya, 2002; Edmundson, 2007; Hung & Chen, 2003; Marginson, 2004; Treuhaft, 2000), the cultural differences empirically documented in this experimental study have implications for designing, developing, and evaluating technology-enhanced learning environments.

The empirical evidence from this study indicates that the informational focus of natural language communication and real world interaction of Anglo-American participants (low-context communication style) carries over to the online interactions. Both technology designers and instructional designers can incorporate this understanding into their practice.

Chinese participants’ preference of embedded discussion compared to threaded discussion has implications for practitioners of online courses and asynchronous

learning networks that still predominantly use threaded discussion boards. It could very well be the case that the socio-technical affordances of current hierarchical tree structured threaded discussion boards might vary systemically across cultural dimensions.

Although the cognitive embeddedness of discourse and knowledge-building have been theorized and empirically evaluated (Suthers, Vatrappu, Joseph, Dwyer, & Medina, 2006; Suthers *et al.*, 2008), social engagement and cultural embeddedness aspects of these design implementations have remained unexamined so far. Instructors and designers of online courses need to consider incorporating more embedded forms of discussion than the threaded discussion boards. They need to consider ways of facilitating the varying degrees of social and cognitive embeddedness in a multi-cultural online classroom setting by using scripts and scaffolding.

The results of this empirical study also suggest that instructional and organizational technology practitioners and designers need to recognize and facilitate both the individual and collective modes of contributions.

Given that both seminal networked learning research (Hiltz, 1994; Mayadas, 1997) and current online learning best practices prescriptions (Moore, 2006) emphasize student collaboration, and since these aspects vary across cultures in traditional classroom settings (Hofstede, 1986) as well as online learning settings (Edmundson, 2007), mono-cultural design assumptions that do not incorporate “alternates for action” might not achieve the best results in terms of student learning processes, outcomes and satisfaction.

4.3. Future work

According to Treuhaft (2000, p. 51) “the diverse multicultural nature of the APEC environment makes online learning very different from most online learning environments.” Increasingly, issues are being identified in the cross-cultural implementation of online learning or e-learning systems which are primarily designed, developed, and evaluated in North America and/or Western Europe contexts (Edmundson, 2007). To help remedy this situation, future work could investigate three models of cultural influence in online learning: (1) culture-specific, (2) culture-comparative, and (3) culture-interactional. Culture-specific work studies online learning in a specific cultural context where learners have a shared sense of identity. Culture-comparative studies of online learning investigate online learning processes and products across cultures. In culture-interactional studies, online learning in intercultural settings is the primary focus. Each of these three models can contribute to a better understanding of online learning and teaching. This research project sought to do this in an experimental setting with intra- and intercultural collaborative dyads. If the initial effort reported in this paper is taken up for further inquiry by the research community, it should lead to a better understanding of cultural considerations in technology enhanced learning settings.

Acknowledgments

I thank my dissertation advisor and research mentor Dr. Dan Suthers for invaluable advice, constructive criticisms, and generous support. I thank the members of my dissertation committee, Dr. Nathan Dwyer, Richard Medina, Marc Le Pape, members of the Laboratory for Interactive Learning Technologies (LILT), faculty and students at the University of Hawaii for their advice and support. Many thanks to Yam San Chee for his critical review and constructive comments. This research project was supported by a NSF CAREER award # 0093505 to Dr. Dan Suthers. The writing of this article was partially supported by NSF award # 0535036 to Dr. Scott Robertson.

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