THE INTERPLAY OF COLLABORATIVE TECHNOLOGY WITH LEARNER CHARACTERISTICS: CONCEPTUAL AND EMPIRICAL EXAMINATIONS

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And we know that in all things God works for the good of those who love him, who have been called according to his purpose. Romans 8:28

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Summary

In recent years, developments in the IT world have resulted in a new wave of collaborative technology (CT) that includes wiki-based software such as PBWorks and Mediawiki. These CTs are becoming widely available, often at no cost, resulting in massive adoption by the IT-savvy, the trend-conscious, and the average IT-literate individual.

Many learning groups are adopting these new breeds of CTs for various purposes in schools and organizations. However, the uptake of these CTs without a clear understanding of their effectiveness is cause for concern. Although a number of studies have been published regarding CT adoption and use, many are descriptive studies or report technical designs. Greater theoretical development and empirical efforts to examine CT effectiveness are in want.

This thesis is a pursuit of theoretical factors and relations that demonstrate the effectiveness of CTs in learning groups. Through the literature review, we have identified several inputs (CT and learner characteristics), processes (task-related and socio-emotional communication activities) and outputs (learning performance and socio-related outcomes) relevant to the use of CTs in learning groups. Based on several theoretical lenses including the functional and psychodynamic perspectives, a theoretical framework for CT effectiveness is developed. Guided by the theoretical framework, three empirical studies were performed.

Study I examines the interplay between CT characteristics, learner characteristics and learning outcomes through a quasi-experiment. CT characteristics investigated were sociability and visibility while learner characteristics examined were age and gender. Among its findings, CT visibility was found to enhance the learning outcomes of academic achievement and solution satisfaction. Besides the direct effects, the study also showed moderating effects of the two dimensions on learning outcomes.

Study II focuses on the communication processes in the learning groups. The role of task-related and socio-emotional communication activities was investigated. Using the survey methodology, a positive and significant direct effect was found between task-related activity and several learning outcomes. Interestingly, socio-emotional activity was positively associated with all learning outcomes except for academic achievement. In addition, the study examined the effects of learner characteristics age, gender, wiki experience, and instructor support on the communication processes.

Study III seeks for an important aspect concerning the social context (CT sociability and proximity) and communication process in affecting learning outcomes. A quasi-experiment was conducted with two different CTs in a team project that spanned Singapore and the United Kingdom. The study demonstrated the saliency of a balance of task-related and socio-emotional activities in moderating the relationship between the CT sociability and learning outcomes as well as proximity and learning outcomes.

Arising from integrative and overall findings, a revised theoretical framework of CT effectiveness is developed and put forth. The current effort provides theoretical and empirical support on the effectiveness of the use of wiki-based CTs in learning groups. In addition to research contributions, the thesis presents practical implications for system designers, educators and learners. The thesis has illuminated factors from the current social context and communication process that affect learning outcomes. Further, the thesis has identified and outlined future research opportunities.

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Chapter 1: Introduction

1.1 Rise and Uptake of New Breeds of Collaborative Technologies

In recent years, developments in the IT world have seen a shift from offline software to online software services. One of the forefronts of this trend is a new wave of collaborative technology (CT) that includes wiki-based software such as PBWorks, Wetpaint, and Mediawiki. These CTs allow the editing of documents online where each revision of the document is tracked. More importantly, these applications turn individual document creation into group workspaces where group members can co-author a single document. Moreover, these CTs are becoming widely available, often at no cost, resulting in massive adoption by the IT-savvy, the trend-conscious, and the average IT-literate individual.

Many individuals are adopting these new breeds of CTs for various purposes in schools and enterprises. For instance, educators and students are employing many of these software applications for their projects and assignments (Deters, Cuthrell, & Stapleton, 2010). A report by the Joint Information Systems Committee in the U.K. documents 26 examples of online collaboration application use in higher education (Minocha, 2009). A U.S. based survey reported that 64% of students in higher education used CT at least several times per month to connect with classmates to study and to work on class assignments (CDW-G, 2010). In K-12 education, a recent survey found that 45% of U.S. districts had 25% or more teachers using CTs e.g., blogs and wiki-based collaboration in their classes (IESD, 2011). This is a 13% increase from the previous year.

Similarly, many organizations are experimenting with CTs (Lee & Bonk, 2010). Gartner (2010) predicts that in 2011 organizations worldwide will spend US$769.2 million on enterprise social software which include CTs such as blogs, wikis, and integrated platforms. An increase of 15.7% from 2010 figures, the technology research company foresees that the rising trend will continue. Moreover, a survey of the Asia-Pacific region found that working

professionals used CTs at least once a week for professional purposes: 27.9% used wikis, 20% used blogs, and 13.1% used social networks (CCH, 2008).

This new breed of CTs has cascaded into our world. However, the uptake of these CTs without a clear understanding of their effectiveness is cause for concern. Although a number of studies have been published regarding CT adoption and use, many are descriptive studies with prescriptive guidelines (Hew & Cheung, 2009). Others provide theoretical explanations and only report technical designs of these CTs (Cress & Kimmerle, 2008; Raman, Ryan, & Olfman, 2005) while other studies are self-reflections without rigorous investigation (Cole, 2009). A few studies on CT effectiveness can be found but are nonetheless limited in terms of some crucial aspects such as a theoretical research model (e.g. Ramanau & Geng, 2009). Greater theoretical development and empirical efforts to examine CT effectiveness are lacking (Forte & Bruckman, 2007; Kane & Fichman, 2009). Moreover, previous studies tended to examine group collaboration using short durations which prevented the examination of mature groups and thus may only have manifested a novelty effect (Chidambaram, 1996; Hew & Cheung, 2009).

1.2 Research Scope and Questions

There are many ways in which individuals can employ CT such as between paired individuals, in small groups, in learning communities and among other combinations of individuals. Although there are several different settings in which to examine CT, the focus of this thesis is on learning groups. For the purpose of this thesis, a “learning group” is defined as a small group of individuals with the shared purpose of achieving certain learning outcomes. A learning group is prevalent in educational settings such as groups formed for the purpose of completing a group project (Arbaugh & Benbunan-Fich, 2006; Rick & Guzdial, 2006). However, learning groups are also possible in organizations, for instance, work teams that are required to produce a shared product, in virtual teams and training groups (Carroll, Rosson, Convertino, & Ganoe, 2006; Chudoba, Wynn, Lu, & Watson-Manheim, 2005). The

terms “group” and “team” are used interchangeably in this thesis. While there are different nuances to the respective terms, they both refer in this thesis to three or more individuals with clearly defined membership who are tasked with a shared product or service (Hackman, 1987).

The notion of learning outcomes is central to the thesis. Learning outcomes are defined as the general outputs as a result of the interaction in a learning group, for instance, intellectual and emotional changes of members in the group. In this thesis, we intend to examine learning outcomes related to the cognitive and social dimensions consisting of learning performance and socio-related outcomes respectively. Learning performance has been the traditional measure of group outcomes (Alavi, Wheeler, & Valacich, 1995; McGrath, 1984). However, socio-related outcomes have been increasingly highlighted as salient (Gunawardena, 1995; Kreijns, Kirschner, & Jochems, 2002; Liu, 2002).

Many researchers are trying to understand how using CT affects learning outcomes (Barron, 2003; Cogburn & Levinson, 2003; Easley, Devaraj, & Crant, 2003; Hughes & Naraya, 2009). Although proponents have highlighted the effectiveness of using CT in learning, many others have realized that certain conditions must exist for higher learning outcomes to emerge (Lipponen & Lallimo, 2004). Moreover, past research has not shown how specific social contexts affect learning outcomes. More in-depth research of CT effectiveness in learning environments is needed (Barron, 2003; Wagner, 2004). In order to address some of the missing gaps in the literature, this thesis intends to investigate how CT use in learning groups affects learning outcomes. The first research question of this thesis is:

1. Does the use of CT affect learning outcomes in groups?

Understanding how CT can be more effective in advancing learning is a central theme in research. CT can be a double-edged sword, facilitating learning outcomes in some ways but discouraging it in other areas (Carte & Chidambaram, 2004; Francescato et al., 2006; Prinsen, Volman, Terwel, & van den Eeden, 2009; Wang, 2010). A key lens that aids understanding

on the effectiveness of CT is known as the functional perspective. This perspective identifies inputs and/or processes to seek to account for CT's effect on learning outcomes (Wittenbaum et al., 2004).

Past research has identified several inputs that appear to affect learning outcomes with CT. In a landmark study, Piccoli, Ahmad and Ives (2001) delineate two key dimensions in technology-mediated learning – the technology and learner dimensions. The technology dimension corresponds to characteristics embodied within the CT itself while the learner dimension refers to human-related aspects of CT interaction and its possible influence on learning.

Rather than looking at CT as a sum of its parts, this thesis adopts a decompositional approach to examine CT as consisting of fundamental parts (Clark & Brennan, 1991; Daly-Jones, Monk, & Watts, 1998). This approach enables us to analyze key characteristics of technology. Based on a literature review, the thesis identifies two CT characteristics, sociability and visibility, for further study as they seem especially salient for this new breed of CT.

As for the learner dimension, the research examines aspects of the learner as well as the learning group. These learner characteristics include age, gender, CT experience, proximity, and perception of instructor support. All of these factors have been shown in several studies to affect learning outcomes (Arbaugh & Benbunan-Fich, 2007; Brandon & Hollingshead, 1999; Jucks, Paechter, & Tatar; Paechter, Maier, & Macher, 2010; Piccoli, Ahmad, & Ives, 2001; Sharda et al., 2004; Swan et al., 2000).

From the functional perspective, CT characteristics and learner characteristics are inputs that affect learning outcomes (Wittenbaum, et al., 2004). This leads to our second research question:

2. Do CT characteristics and learner characteristics affect learning outcomes?

Some research has highlighted the moderating effect of learner characteristics in the relationship between CT and learning outcomes (Chang & Lim, 2005; Fjermestad, 1998; Sharda, et al., 2004). Basically, a two-way dynamic occurs between factors to impact outcomes (Sharda, et al., 2004; Terborg, 1981). It is inadequate to conceive of a single relationship that affects learning outcomes, rather, a multidirectional interaction exists. The thesis therefore intends to focus on the interplay of these two dimensions. The next research question is:

3. How does the interplay of CT characteristics and learner characteristics affect learning outcomes?

In additional to inputs, the functional lens suggests that communication processes also affect learning outcomes (Brandon & Hollingshead, 1999). Pioneer research by Bales (1950) showed that a group is in a continual state of dividing its time and work between instrumental (task-related) and expressive (socio-emotional) needs. Consequently, processes consisting of two main types of communication activities – task-related and socio-emotional needs are examined. Some literature has tended to ignore socio-emotional activity and focus only on task-related communication (Bonk, Malinowski, Angeli, & East, 1998; Heo, Lim, & Kim, 2010). However, other research has highlighted the importance of investigating expressive processes in addition to task-related processes as both types of communication activities can affect learning outcomes (Flammia, Cleary, & Slattery, 2010; Liu, 2002). This provides the basis for the fourth research question.

4. What are the roles that task-related and socio-emotional communication processes play in affecting learning outcomes?

Based on the integration of theoretical perspectives and prior conceptualizations, a conceptual framework is developed to examine CT effectiveness. Three empirical studies are designed and conducted to test the relationships proposed in the framework. These studies all examine wiki-based CTs which have been popularly adopted by learning groups. Consequently, the

findings of the thesis will be pivotal for future research and practice. The next section deliberates on potential contributions of the thesis.

1.3 Potential Contributions

Through answering these research questions, the thesis has a four-fold purpose. The first goal is to develop a framework for assessing CT effectiveness in the light of these new breeds of CT. Based on the literature, two theoretical lenses, the functional and psychodynamic perspectives, have been identified which serve to further understanding of the complex relationship between CT and learning outcomes. A framework will be developed based on these underlying theoretical perspectives. The resultant framework is considered a middle-level theory that can inform research and the practice of both CT development and technology-mediated learning (Sadler-Smith, 2006).

The second objective is to determine the effectiveness of these newer CTs in learning groups. Wikis, innovations of the new wave of CTs, are the focus of this thesis. Many existing studies on wikis are descriptive in nature or consist of technical designs (Hew & Cheung, 2009). This thesis fills the missing gap by providing an empirical investigation of the effectiveness of this new breed of CT.

Third, the thesis identifies several pertinent factors that may serve to enhance the effectiveness of CT. For CT characteristics, the study delineates two salient characteristics that are relevant to the emerging technology. Five learner characteristics that pertain to the learners and learning group are also identified. Moreover, task-related and socio-emotional activities are examined to better understand aspects of the processes involved in learning groups with CT (Bales, 1950). Theoretical and practical implications are suggested from the study of these salient factors which provide future directions for researchers and practitioners.

Fourth, rather than solely examining task or cognitive outcomes, a broad-based approach consisting of both learning performance and socio-related outcomes is theorized. Past

literature has predominantly disregarded or been biased against socio-related outcomes (Liu, 2002) but other research has shown evidence for the utility of examining these non-task-related outcomes (Kreijns, et al., 2002). Thus, the thesis will provide a more holistic approach to learning outcomes.

1.4 Thesis Organization

The organization of the thesis is as follows.

Chapter 2 provides a review of relevant literature. Two pillars of research literature serve as the foundations for the study: small group and educational psychology. The thesis reviews several theoretical perspectives from the small group literature and describes the general group effectiveness literature stemming from Information Systems (IS), organizational psychology, and social psychology. Next, relevant educational psychology theories and pedagogies are delineated followed by empirical work on group effectiveness research in the education domain. Subsequently, an overview of CT and its effectiveness in groups is discussed. The review also goes in-depth to illustrate the various CT characteristics. Finally, the review examines CT use in learning groups in terms of existing CT and the newer breeds of CT.

Chapter 3 elaborates on the overall theoretical framework of the thesis. Based on the literature review, a theoretical framework is conceptualized that consists of CT characteristics, learner characteristics, communication processes and learning outcomes. Each element of the framework will be discussed followed by a description of the research approach of the study.

Chapter 4 details the first empirical study, “The Interplay of Collaborative Technology with Learner Characteristics: *Foundational* Examinations” (Study I).

Chapter 5 elaborates on the second empirical study, “The Interplay of Collaborative Technology with Learner Characteristics: *Process* Examinations” (Study II).

Chapter 6 describes the third empirical study, “The Interplay of Collaborative Technology with Learner Characteristics: *Interactional* Examinations” (Study III).

Chapter 7 is an overall discussion of the findings from the three studies. A revised theoretical framework is proposed.

Lastly, chapter 8, provides a conclusion. It summarizes key findings, describes the contributions of the thesis to both research and practice, and discusses the overall limitations and future research opportunities.

Chapter 2: Literature Review

With a new wave of accessible CTs, many groups are adopting these CTs for learning and training. In this thesis, we intend to examine the effect of CT in learning groups. Two academic domains form the pillars of this thesis: theoretical perspectives from small groups and educational psychology. Theoretical and empirical research of the effectiveness of groups from both these domains will be reviewed. The advent of CT especially new breeds of CT provides a layer of support for learning groups. This layer of the review will elaborate on the effectiveness of CT in general groups as well as the characteristics of CT. At the apex of the thesis is the spotlight on facilitating learning outcomes with CT. Learning effectiveness literature on traditional CT and new breeds of CTs will be reviewed. Our framework for discussing the relevant literature is illustrated in Figure 2.1.

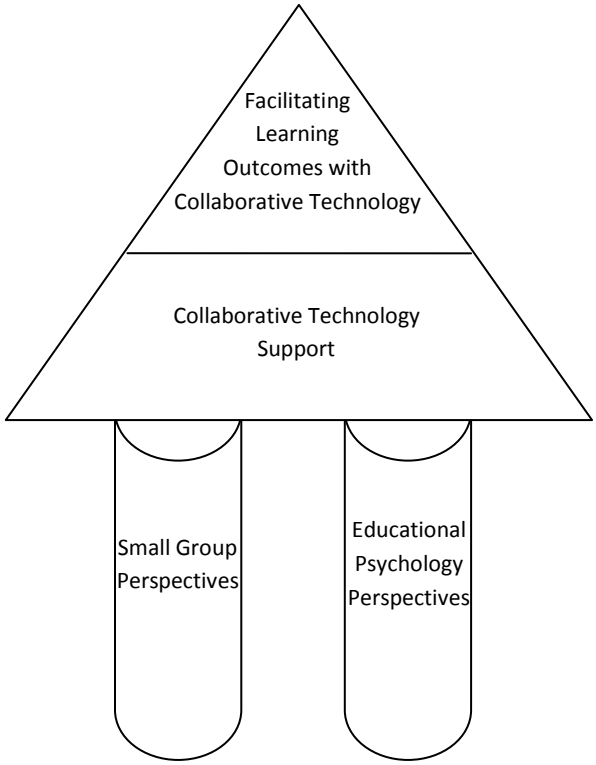


Figure 2.1 A Framework for Discussing Relevant Literature

2.1 Small Group Perspectives

There are many ways of examining groups and past research has identified several perspectives through which groups have been studied (Poole, Hollingshead, McGrath,

Moreland, & Rohrbaugh, 2004; Wheelan, 2005). Poole et al. (2004) surmise that over the past 50 years there have been nine general theoretical perspectives of small groups. These perspectives are: the psychodynamic, functional, temporal, conflict-power-status, symbolic-interpretive, social identity, social-evolutionary, social network, and feminist perspectives. These different perspectives arise from various disciplines as well as differing group focus and methodology. However, these perspectives can overlap in certain areas but still contain conceptually distinct focuses. Although the conceptual bases for these nine perspectives differ, they often overlap in certain research practices such as the types of topics and populations studied (Berdahl & Henry, 2005; Poole, et al., 2004).

Of these nine, the functional and psychodynamic perspectives are the most relevant to this thesis as they both highly value group effectiveness. The other perspectives tend to focus on other topics such as the self-concept (e.g. social identity theory), group inputs (e.g. social-evolutionary perspective), and dynamic processes (e.g. temporal and feminist perspectives). (See Poole et al. (2004) and Wheelan (2005) for more details of the other perspectives.) Following a deliberation of the functional and psychodynamic perspectives, general group effectiveness literature will be reviewed.

2.1.1 The Functional Perspective

The functional perspective is seen as the normative approach to theorizing group performance and has been predominantly used in IS and organizational behavior disciplines. The functional perspective views group effectiveness as a "function of inputs and/or processes" (Wittenbaum, et al., 2004, p. 18). The functional perspective derives from three primary assumptions: (1) groups are goal-directed, (2) the ability to assess tangible group outcomes, and (3) an input-output relation can be determined by studying group interaction processes (Cummings & Ancona, 2005; Wittenbaum, et al., 2004). Groups that are goal-directed have shared aims such as delivering a joint report. As for the second assumption, it is accepted as a given that groups can be assessed based on a normative standard. Group members are expected to meet these standards in a rational manner, for instance, performing a thorough

cost-benefit analysis before making a decision. Lastly, the input-output relation could be determined based solely on inputs or it could be mediated by processes during group interaction such as communication and coordination. These processes would affect the final group outcome.

The inputs to a group in the functional perspective may be derived internally (i.e., within the group) as well as externally (i.e., outside the group boundary). This perspective has resulted in theory suggesting that group composition, structure, task-related goals, and interaction processes affect outcomes of the group. These theories predict group performance as well as emphasize reasons why group performance can be improved. The functional perspective also posits that conceptual relations are sequential and causal in nature as inputs affect group interaction processes and ultimately affect group performance. Research and theory in the functional perspective includes work by Hackman (1987) and Cramton (2001).

The functional perspective is key to understanding task-performing groups as this view prescribes group inputs and sometimes even interacting processes that contribute to task success. At the same time, one severe limitation of this perspective is its focus only on task performance (Cummings & Ancona, 2005; Wittenbaum, et al., 2004). The functional perspective is unable to account for groups whose main goal is socio-related outcomes such as would be commonly found among therapy and social support groups.

2.1.2 The Psychodynamic Perspective

In contrast to the emphasis on the function of groups, the psychodynamic perspective focuses on social processes. Unlike the focus on task performance as an outcome that is the core of the functional perspective, the psychodynamic perspective highlights the positive change in the group. The psychodynamic perspective views group processes as biologically-based and directs attention to the relationship between the non-conscious and conscious processes of interpersonal interaction (Berdahl & Henry, 2005; Mcleod & Kettner-Polley, 2004). Groups

are seen as comprising internal structures and dynamics. This perspective stems from the disciplines of social psychology and psychotherapy.

The psychodynamic perspective has produced two schools of thought: the psychoanalytic and humanistic schools (Mcleod & Kettner-Polley, 2004). The psychoanalytic school centers on a medical model and includes work by noted theorists like Freud (1922) and Bion (1961). The humanistic school centers on the education and human development model and representative theorists are Lewin (1947) and Moreno (1953). Despite many differences, the two schools of thought share the following assumptions which lay the foundation for the psychodynamic perspective.

The assumptions are: (1) emotional and non-conscious processes exist within all human groups, (2) emotional and non-conscious processes affect group outcomes, and (3) group effectiveness arises as a result of highlighting the group members' non-conscious processes. Firstly, it is assumed that all human beings live on at least two levels, the conscious and the unconscious, which pertain respectively to thoughts and feelings. The psychodynamic perspective emphasizes that human beings develop emotions and personality and that this development principally occurs when human beings are interacting in a group rather than independently self-developed. The next assumption is that despite the conscious processes of individuals even to suppress or subvert them, non-conscious processes have the ability to affect the quality of interpersonal interaction and task performance. The third assumption is that only when non-conscious processes and internal structures are made aware or conscious to group members can the group rationalize or make better decisions, which in turn will result in improved group performance.

The strength of the psychodynamic perspective is that it allows researchers to study group effectiveness by examining how group members change. This includes examining group member characteristics that affect the group experience and/or measuring group outcomes due to group interventions. A limitation of this perspective, however, is the fragmented state of

the psychodynamic field which arises from disparate disciplines. The different terminologies used may prevent common understanding among researchers and practitioners and limit the growth of this theoretical perspective. A second major limitation is that the main focus of inquiry lies beyond the realm of mere observable behaviors. It requires making inferences and discerning meanings, often obtained through subject self-reports, and tends to be difficult or impossible to independently verify.

The functional and psychodynamic perspectives are influential theoretical lenses in which to examine small group behavior. As no one perspective can fully explain the rich sphere of group dynamics, it is valuable to involve relevant and disparate perspectives to gain a better understanding of group behavior (Wittenbaum, et al., 2004). In the next section, group effectiveness research literature from the IS, organizational psychology, and social psychology domains will be reviewed. This research arena has contributed to an understanding of several factors that affect group performance in general.

2.1.3 Group Effectiveness

As mentioned, the functional perspective examines inputs, processes in order to evaluate group effectiveness i.e., the outputs This has resulted in the input-process-output model or I-P-O model for short which has become the dominant paradigm in the literature (Ilgen, Hollenbeck, Johnson, & Jundt, 2005). This model views the group as a system where inputs enter and contribute to the system followed by processes that interact within the system, and outputs that are the effects of the system and which exit it. In this model, a direct relationship is specified between inputs and processes; in turn, processes directly affect outcomes.

One of the first studies of group effectiveness demonstrates the I-P-O approach. McGrath (1964) proposed a research model that defined group effectiveness as a function of input factors, the group interaction process and two output categories. Three types of input factors are described: individual-level (member skills, attitudes, personality), group-level (structure, cohesiveness, size), and environmental-level (task, reward structure, stress). The outputs are

in terms of performance (quality, solution speed, number of errors) and the category termed "others" which includes member satisfaction, group cohesiveness, attitude change and sociometric structure.

The study is notable as it provides a simple and useful way to view group effectiveness. Moreover, the model recognizes the importance of the social aspect of the team experience by denoting another category for it rather than focusing only on performance. A weakness is that the group interaction process, which is how the team performs the task, is not elaborated on in the model.

Another foundational study on group effectiveness resulted in the normative model of group effectiveness (Hackman, 1987), illustrated in Figure 2.2. Hackman (1987) posits that two input dimensions – organizational context and group design affect the process criteria of effectiveness which subsequently affects the outcome of group effectiveness. The research suggests that the processes: level of effort team members exert, the amount of knowledge and skill applied to the task and the appropriateness of task-performance strategies are an intermediate indicator of group success. In addition, group synergy can moderate the process indicators while material resources affect the ultimate group effectiveness. This model is a slight departure from a straightforward I-P-O approach. However, there was no empirical research to back-up the proposed relationships.

Cohen and Bailey (1997) reviewed past research of teams in organizational settings and developed a heuristic model of group effectiveness (Figure 2.3). The research model consists of environmental factors, design factors, processes, group psychological traits and effectiveness as outcome. The general postulation is that design factors affect processes and group psychological traits which subsequently affect group outcomes. Design factors can also directly affect outcomes. In addition, the model conjectures that the environment factor (e.g. industry characteristics) affects the input (e.g. design factor), suggesting the importance of the social context in a group.

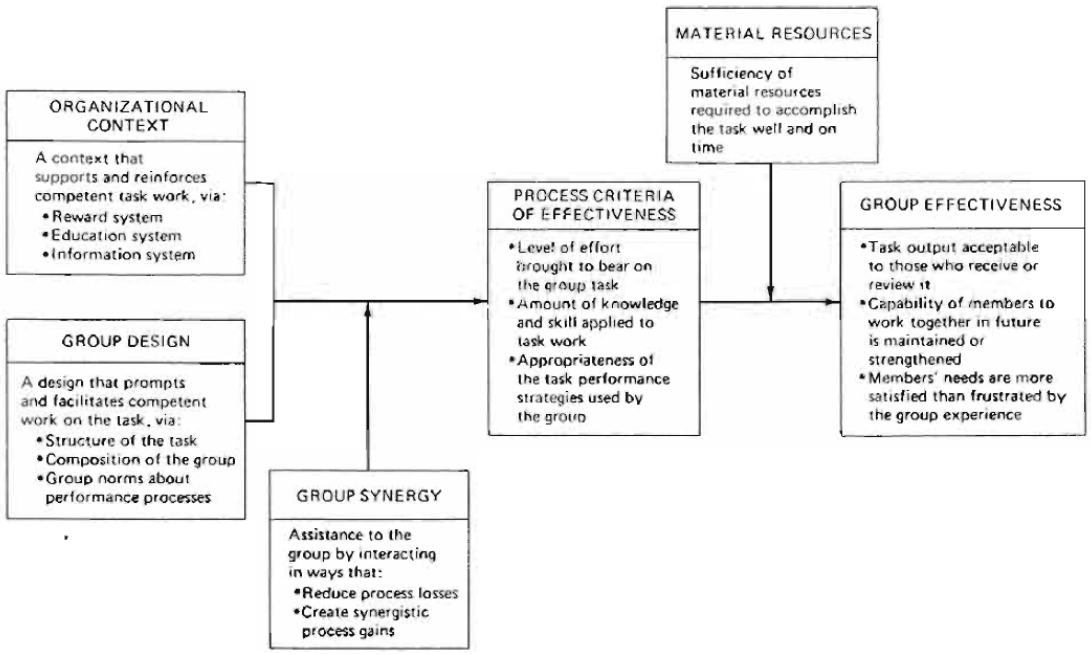


Figure 2.2 Normative Model of Group Effectiveness (Hackman 1987)

The research proposed the design factors: task (e.g. task autonomy), group (e.g. size), and organizational context (e.g. rewards) variables. Group processes such as communication and conflict can occur among team members as well as individuals external to the team. Group psychosocial traits are states of the group regarding a common understanding, belief, or emotional tone. They include norms, cohesiveness, shared mental models, and group affect. The model predicts that both group processes and group psychological traits influence each other. Lastly, outcomes are in terms of performance, attitude and behavior.

The research is notable in two ways. First, it attempts to break away from the traditional I-P-O approach for instance, by suggesting that environmental factors affect inputs which subsequently affect processes and the final effectiveness. However, the research still has the frame of an I-P-O model in which there are inputs, processes and outputs. Second, the model extends the notion of the processes in group effectiveness by suggesting two types of processes. Unfortunately, the study did not elaborate on how the internal and external processes could affect each other.

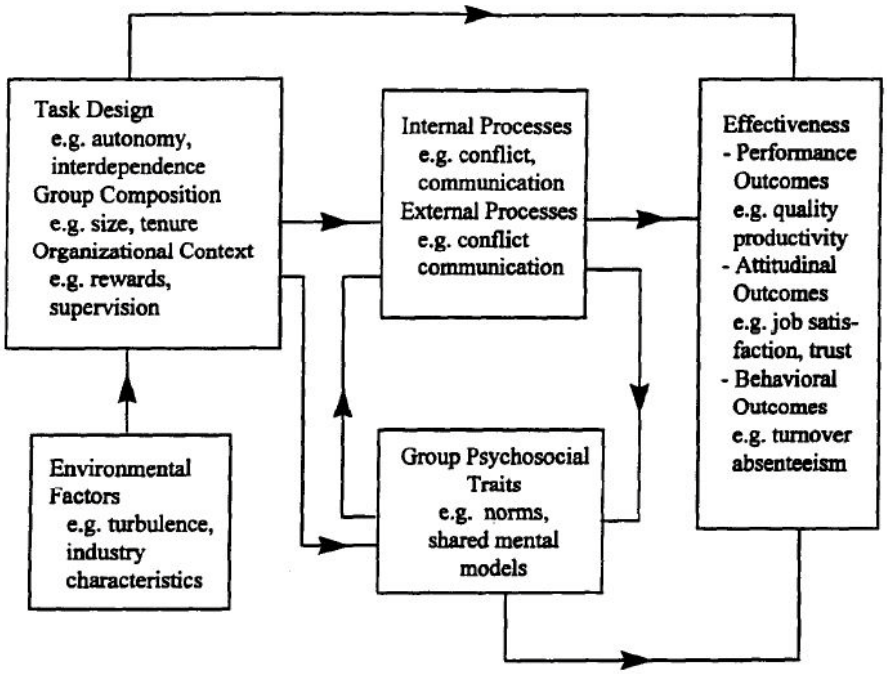


Figure 2.3 Heuristic Model of Group Effectiveness (Cohen & Bailey, 1997)

Other group processes have also been identified. One important process is that of process gains and losses. Steiner (1972) was the first to articulate the unitary effect of process losses and gains in a group. As individuals come together to form a group, the group possesses the ability to engage in productive as well as destructive activities. Process losses are negative influences generated by individuals in a group; these lower the total performance of the group. More research has examined the negative effects of groups and several processes have been identified including conformance, dominance, evaluation apprehension, free riding, information overload, and production blocking (Dennis & Wixom, 2001; Hiltz & Turoff, 1985; Mejias, 2007; Straus, 1996; Weisband, Schneider, & Connolly, 1995). On the other hand, process gains are positive influences generated by individuals in a group and these increase the total performance of the group. Nunamaker et al. (1991) describes five types of process gains: more information, synergy, more objective evaluation, stimulation and learning.

An emerging area on group processes is termed “teamwork processes”. Teamwork processes are interdependent team activities pertaining to thoughts, actions and feelings that each group member engages in to achieve a joint goal (Marks, Mathieu, & Zaccaro, 2001; Salas, Rosen,

Burke, & Goodwin, 2008). In an integration of extant literature, Salas et al. (2005) coin a "Big Five" of teamwork processes as well as three crucial coordinating mechanisms. The five teamwork processes are team leadership, team orientation, mutual performance monitoring, backup behavior and adaptability. These are dovetailed by three core coordinating mechanisms: shared mental models, closed-loop communication and mutual trust (Salas, et al., 2005).

Besides these theoretical examinations, empirical data has examined several of these inputs and processes that affect outputs. For instance, Campion et al. (1993) performed a survey of 391 employees in 80 different existing work groups. The study found that group effectiveness (productivity, satisfaction) was positively correlated with five categories of characteristics: job design (self-management, participation, task variety), interdependence (interdependent feedback and rewards), composition (size), context (managerial support), and process (potency, workload sharing, communication and cooperation within the group). The research suggests that these input and process factors all have an impact on the effectiveness of groups.

The above-mentioned studies have focused much on the task as part of the functional perspective. However, there has been some research that has extended the normal task-focused function of group effectiveness. One example is the work of Gladstein (1984) who extended McGrath's model and posited that two types of group processes affect group effectiveness (performance and satisfaction). The study identified group processes not only from the functional perspective but also from the psychodynamic perspective, principally the humanistic school. From the functional or task function view, the work identified the processes of strategy discussion, weighting individual inputs and boundary management. From the humanist school, group processes identified are open communication, supportiveness, and a lack of interpersonal conflict.

In addition, the research proposed that inputs (the group-level and organizational-level) affected the group process as well as directly affecting the outputs. The model is illustrated in

Figure 2.4. Also, in contrast to the normal I-P-O model, Gladstein (1984) proposed that the group task would moderate the relationship between group process and output, rather than serve as an input. This interaction ties in with research that suggests that a two-way dynamic occurs between factors to affect outcomes (Terborg, 1981). Task type was in terms of complexity, interdependence and environmental uncertainty. Among its arguments, the paper suggests that strategy discussion would improve group performance only when the task was complex; if it were a simple task, the group could follow the standard operating procedure without much discussion.

The model was tested using a survey of 326 employees representing 100 sales teams in the communications industry. The study found that inputs generally affected the group processes which influenced group effectiveness. Group performance was measured in terms of perceived group effectiveness as well as actual sales revenue. There was more support for perceived group effectiveness as compared to sales revenue, suggesting that individuals' "implicit theories" were more dominant compared to actual group effectiveness. The inputs - organizational tenure, leadership, and training - were found to be associated with group effectiveness. However, group task did not moderate the relationship between group process and outcomes possibly because of a lack of variance in the authentic tasks performed by the groups.

Another interesting finding was that the group processes: open communication, supportiveness, conflict, weighting, discussion of strategy, when analyzed by the researcher, was found to be one construct, labeled, intragroup processes. Boundary management was seen as another separate construct. The research suggests that groups perceived that activities internal to the team were different from activities concerning the external organizational environment. This also implies that differences in origins of process activities are more subtle than theoretically conceived. Nevertheless, the study is one of the few studies that examine non-task processes. It also provides a more complex understanding of group effectiveness, departing from the simplistic I-P-O approach.

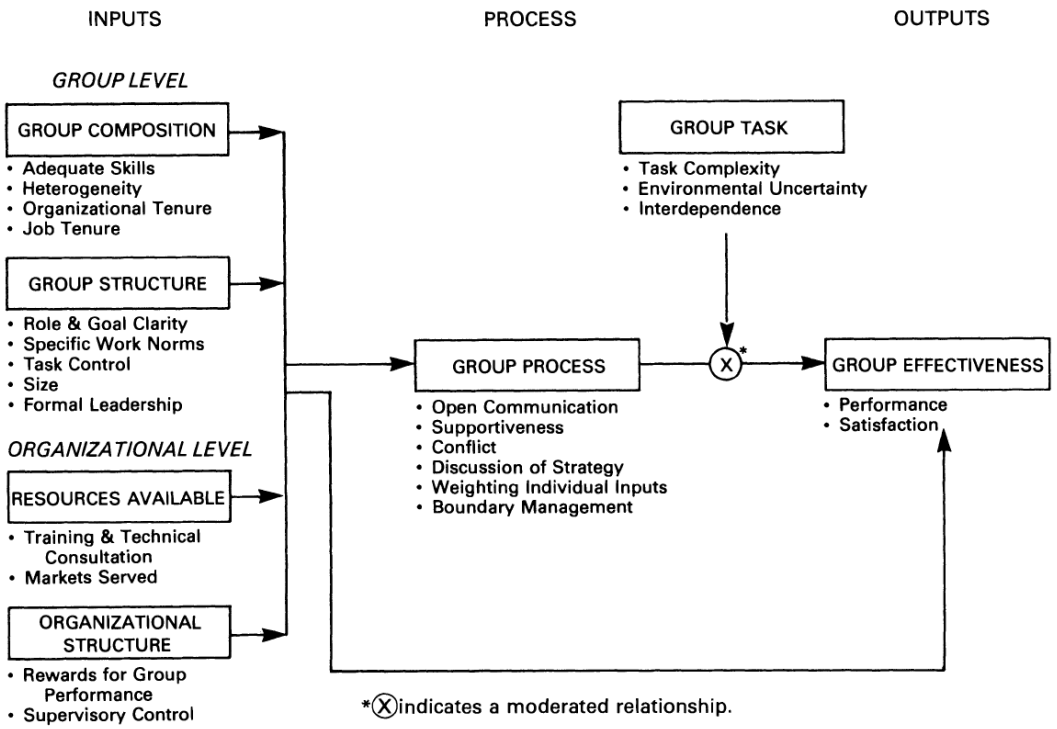


Figure 2.4 General Model of Group Behavior (Gladstein, 1984)

Another study has also integrated the two theoretical perspectives. Rousseau, Aubé, and Savoie (2006) dichotomize teamwork processes into two overarching aspects: regulation of team performance and management of team maintenance. The former stems from the functional perspective and refers to the accomplishment of task-related goals which is done in a sequential manner of preparation (e.g. goal specification), execution (e.g. information exchange), evaluation (e.g. performance monitoring) and adjustment (e.g. backup behavior). As for the latter, the research identifies psychological support and conflict management as specific activities. These socio-emotional activities pertain to personal or interpersonal issues in the group and can affect the maintenance of the team; these originate from the psychodynamic perspective. The study observes that little research has focused on team maintenance in the literature.

Ilgen et al. (2005) in a review of work groups calls for the development of the IMOI model, which stands for “input-mediator-output-input”, to replace the I-P-O model. The “M” replacing the “P” represents mediators and moderators that could affect outputs. The addition of the “I” at the end represents feedback loops that could affect the group over time. Lastly,

the removal of hyphens between the letters indicates that the linkages between the variables are not sequential; rather, these relationships may be conditional and nonlinear.

The research declares that the I-P-O approach is too simplistic to summarize research about group effectiveness and could constrain further conceptualizations. The review organizes the literature according to the stages in the IMOI model: the IM stage (termed “forming”), the MO phase (termed “functional”), and the OI phase (termed “finishing”). Research in the forming stage centers around affective mediators, behavioral mediators, and the structure of cognitive mediators. For the functional stage, key issues in past research are with regard to bonding (among diverse team members and managing conflict), adapting (under novel conditions and workload sharing) and learning (from minority members or the experts). In contrast, literature on the finishing phase is sparse and there have only been theoretical conceptualizations of such work, for instance, reasons why groups disband.

However, some researchers have cautioned against this move toward a more complex model (e.g. Salas, 2008). The concern is that research in this vein may become too radical and result in disconnections with fundamental principles in the behavioral sciences. These researchers support the I-P-O model which has been robust and flexible, allowing researchers to adopt various perspectives within the same essential frame. Another criticism of Ilgen’s (2005) work is that the IMOI model might not be the best approach to frame the next phase of group effectiveness research. The IMOI model might prove too intricate for hypothesis testing and modeling. Rather, the I-P-O model is sufficiently robust and allows further theoretical exploration and empirical research.

In sum, group effectiveness research has outlined several inputs and processes that affect the task performance. These have mostly been examined from an I-P-O approach. However, some research has modified the I-P-O model to provide a more complex and somewhat holistic understanding of group effectiveness.

Next, relevant conceptual and empirical literature will be reviewed in the domain of educational psychology.

2.2 Educational Psychology Perspectives

Educational psychology is an evolving science that has generated several theories of learning as well as pedagogies of instruction (Bransford, Brown, & Cocking, 2000). It is not the aim of this thesis to review all the learning theories or pedagogies. Rather, the thesis focuses on learning theories and pedagogies related to collaborative learning. (Please see Anderman et al.(2006), Leidner and Jarvenpaa (1995), and Mayes and de Frietas (2004) for further details of learning theories and pedagogies).

Before discussing the details of the theoretical perspectives, we first define the terms "collaborative learning" and "cooperative learning". These terms have often been used together or kept separate (Roschelle & Teasley, 1995). Collaborative learning in general has been defined as "a situation in which two or more people learn or attempt to learn something together" (Dillenbourg, 1999, p. 1). On the other hand, cooperation emphasizes the delivery of a large task via divisible team roles. Each member is responsible for a particular aspect of the task which is done individually after which it is combined with the other member's portions to complete the whole task (Roschelle & Teasley, 1995). McConnell (2000) further distinguishes that in cooperation an external authority such as the teacher encourages cooperation by structure and rewards. In sum, cooperation is characterized by stricter division of labor, task specialization, individual responsibility for part of the final product, and teacher intervention (Jones, Cook, Jones, & de Laat, 2006). On the other hand, collaborative learning emphasizes the co-production of knowledge building through activities done together. Group members are mutually engaged in completing the task. Also, collaboration seems to emphasize group work among peers without any intervention from an authority figure, in other words, self-directing teams (McConnell, 2000). Key characteristics in collaboration are

then synchrony of problem solving, shared creation, dialogue, and independence from teachers (Leidner & Jarvenpaa, 1995).

Despite the differences among these two concepts, there are much more similarities between the two which make it difficult to separate them. Kirschner (2006) reviewed the commonalities between collaboration and cooperation noting that learning is active, the teacher is a facilitator, teaching and learning are shared experiences, students participate in small-group activities, students take responsibility for their learning, students are stimulated to reflect on own assumptions and thought processes, and social and team skills are developed through the give-and-take of consensus-building. This is in agreement with Johnson and Johnson (1998) who note that both these terms involve the instructional use of small group activities in maximizing an individual and the whole group's learning. Working in small groups, students perform collaborative tasks such as solving complex problems, researching and writing reports, and discussing issues (Slavin, 1987). Moreover, in actual practice, researchers have found that collaborating groups tend to divide up tasks before integrating tasks together – choosing to cooperate rather than collaborate (Dillenbourg, 1999; Geer & Barnes, 2007). Geer and Barnes (2007) point out that collaboration seems like the "holy grail which seems beyond the reach of most groups" (p.125). In that sense, this thesis agrees that it may be hard for learning groups to achieve true collaboration. Rather, groups will encompass elements from both cooperative and collaborative approaches.

This thesis is aligned with researchers (Jones, et al., 2006; Kreijns, et al., 2002) who acknowledge the ongoing debate but realize that the similarities of the two concepts outweigh the differences. Cooperative learning and collaborative learning are highly related terms and cannot be separated. For clarity's sake, the term "collaborative learning" is used for the rest of this thesis.

The theoretical base for collaborative learning stems from social constructivism (Bryceson, 2007; Duffy & Jonassen, 1992; Leidner & Jarvenpaa, 1995). Before going into the details, an

overview of educational psychology is in order. There have been many ways of categorizing learning theories, however, most research tends to agree that there are two main paradigms in educational psychology: objectivism and constructivism (Arbaugh & Benbunan-Fich, 2006; Leidner & Jarvenpaa, 1995). Each of these paradigms can be viewed as a learning theory but each also contains derivations of theories and perspectives in which to understand learning.

Objectivism, also known as behaviorism, is the traditional learning theory that focuses on the observable aspects of the environment. Learning arises as a result of connections between stimuli and responses (Bransford, et al., 2000). This theory posits that learning is the modification of particular behaviors occurring in particular situations. The central tenant is that target behavior can be learnt or enforced through repetition and correction. Thus, education is a process of knowledge transfer from the expert teacher to the novice student. Its theoretical bases include connectionism (Thorndike, 1913), classical conditioning (Pavlov, 1927) and operant conditioning (Skinner, 1953).

On the other hand, a competing theory, constructivism, has become a dominant perspective in educational psychology (Duffy & Jonassen, 1992; Leidner & Jarvenpaa, 1995). It holds that knowledge is constructed in the minds of individuals reflecting on their own experiences (Duffy & Jonassen, 1992). Instead of passively receiving information, individuals are goal-directed agents who actively seek information (Bransford, et al., 2000; Miles, 2003). The central tenant is that individuals construct knowledge and meanings based on what they already know and believe. The theoretical bases include developmentally-oriented theories such as the theory of cognitive growth (Bruner, 1996), sociocultural theory (Vygotsky, 1978) and active learning perspectives e.g., self-directed learning (Dewey, 1906; Strijbos, Martens, & Jochems, 2004).

A key theme in constructivism is the need for authentic social contexts (Arbaugh & Benbunan-Fich, 2006; Barab & Duffy, 2000). Learning is influenced by the social world, the cultural context and community as knowledge-making is inseparable from the environment in

which the meaning was interpreted from. Thus, constructivism emphasizes authentic tasks in a meaningful context rather than abstract presentation of common concepts removed from actual practice (Mayes & de Freitas, 2004).

Social constructivism is one important derivation of constructivism (Arbaugh & Benbunan-Fich, 2006; Bryceson, 2007). Sometimes known as socio-constructivism, the cooperative learning model or the collaborative learning model (Leidner & Jarvenpaa, 1995), social constructivism broadens the interaction of the learner with objects, to the interaction of the learner with other individuals (Vygotsky, 1978). This theory expounds that knowledge is socially constructed through interaction with others (Bryceson, 2007; Hung & Nichani, 2001). Learning is a social process involving interpersonal exchange, participation in relevant discourse and joint activity (Crook, 1994). For instance, individuals can engage in inquiry with their learning group in an open and friendly atmosphere. This allows clarifications and feedback as well as the sharing of alternative views and promotes the development of higher order cognitive processes (Glasser & Bassok, 1989). This dialogue also helps individuals gain new shared knowledge (Duffy & Jonassen, 1992). In essence, the focus in socio-constructivism is on learning from others rather than only learning with others (Arbaugh & Benbunan-Fich, 2006).

Social constructivism has resulted in the design of several pedagogies including problem-based learning, anchored instruction, and project-based learning (Alavi, et al., 1995; Gomez, Wu, & Passerini, 2010; Heo, et al., 2010; Leidner & Jarvenpaa, 1995; Mayes & de Freitas, 2004; van der Pol, Admiraal, & Simons, 2006). All these pedagogies accentuate learning in small groups. For instance problem-based learning entails a group of students working together to solve problems (Alavi, 1994; Arts, Gijselaers, & Segers, 2002; Barrows & Tamblyn, 1980). In problem-based learning, the relevant knowledge and skills has not been acquired before the launch of the problem. The problem questions provide the starting point for the learning activity and the analysis of the problem results in learning for the individuals in the group.

2.2.1 Group Effectiveness

Research has consistently suggested that collaborative learning in which students learn in groups outperforms students learning individually (Arbaugh & Benbunan-Fich, 2006; Hiltz, Coppola, Rotter, Turoff, & Benbunan-Fich, 2000; Johnson & Johnson, 1989; Jonassen & Kwon, 2001). Johnson and Johnson (1989) performed a meta-analysis of 754 studies comparing between students learning in groups as compared to students learning solely as individuals. The meta-analysis examined three outcome areas: effort to achieve, positive interpersonal relationships, and psychological health. For effort to achieve which included performance measures such as tests and grades, the research reported an effect size of 0.61 for cooperative learning as compared to individual learning. For positive interpersonal relationships, interpersonal attraction and social support was measured. An effect size of 0.62 and 0.72 was found respectively. For psychological health, self-esteem was the indicator. The effect size of self-esteem for cooperative learning over individual learning was 0.45. Based on their results, the research advocates that collaborative conditions foster greater cognitive gain as well as higher affect as compared to individual learning conditions.

In another meta-analysis, Lou, Abrami and d'Apollonia (2001) examined 486 studies but this time looking at the differences between small group and individual learning with computer technology. The research measured learning achievement (achievement scores for each learner measured by post-tests), group task performance (measured by performance scores of the task), and several process measures such as use of strategies (appropriate plans to complete the task) and perseverance (completing and not giving up on the task). The research reported an effect size of 0.15 for learning achievement for small group learning as compared to individual learning. As for group performance, an effect size of 0.31 was found when learners were in learning groups completing a group task as compared to individually completing the task. In addition, the research reported that group learning as compared to individual learning resulted in an effect size of 0.33 for using appropriate learning or task strategies and an effect size of 0.48 for greater persistency on tasks. The results of the meta-

analysis suggest that more learning will occur among people learning in groups as compared to people learning individually.

Bernard et al. (2004) performed a meta-analysis of 232 studies comparing between synchronous and asynchronous distance education. The research also examined the influence of pedagogy in affecting results. Through assessing R^2 changes in the regression model, the research found that pedagogy was important in predicting outcomes. Specifically, the use of problem-based learning strategies enhanced achievement (objective measures such as tests) and attitudes (subjective measures such as evaluation of course or satisfaction) for asynchronous distance education. The research suggests that collaboration among learners improves the achievement and attitude outcomes in distributed environments.

Arbaugh and Benbunan-Fich (2006) examined 40 online MBA modules and classified them into individual and group oriented activities based on semi-structured interviews with module instructors. The research then surveyed the students who took the modules. Based on 579 respondents, the study found a significant difference in perceived learning between the two orientations. There was greater perceived learning for modules involving collaborative learning as compared to those only with independent learning. Based on their evidence, the study argues for the effectiveness of the collaborative learning model.

In sum, the education literature has revealed that collaborative learning enhances learning outcomes[1]. Empirical research in both face-to-face and technology-mediated environments has not refuted the claim that collaborative learning in groups is ineffective.

The availability of CT has added another layer to the effectiveness research. CT has been adopted to support learning groups in education and organizations. To investigate the phenomena, the next section elaborates on CT, CT and group effectiveness research as well as CT characteristics.

[1] The thesis notes that while collaboration is widely promoted, it is seen as complementary to individual learning as not all situations and tasks suit learning in groups (Cohen, 1994).

2.3 An Overview of CT

Many terms have been used to describe technologies used by groups. For instance, groupware (Johansen, 1988), computer-mediated communication (CMC; Hiltz & Turoff, 1985), group decision support systems[2] (GDSS; DeSanctis & Gallupe, 1987), and collaborative information technologies (Karsten, 1999). To increase clarity, this thesis uses the umbrella term CT to describe the various technologies used by groups.

Some background in the evolution of CT is helpful to understanding what exactly CT refers to. Grudin (1994) delineates three categories of IT that have been developed (Figure 2.5). Starting with mainframe systems, these were the first commercially available IT developed in the 1960s for organizations. As the cost of computers became cheaper, the micro and mini-computers were invented. These computers were used by individuals and the focus was on developing systems for individual users such as office productivity software. The next trend was the development of CT. Several reasons account for the rise of CT: cheaper computers available to members of the group, development of network standards and infrastructure including the Internet, users maturing in their usage of computers, and developers seeking to enhance their product offerings (Grudin, 1994; Wheeler, Dennis, & Press, 1999).

These evolving contexts promoted the development of many different types of CT with the aim of enhancing communication, collaboration, and cooperation for groups. For instance, Lotus Notes™ developed by IBM is considered the first commercial CT (Karsten, 1999). Another example is GroupSystems™ developed by the Ventana Corporation (Nunamaker et al., 1991). Many of these early CT were relatively expensive and proprietarily built. They were also difficult to access. For instance to use GroupSystems™, individuals had to go to a specialized room equipped with the technology. Content discussed was only made known to the participants involved.

[2] Group decision support systems subsequently became known as group support systems (GSS). The dropping of the term "decision" reflected the increasing mass usage of the CT for tasks other than decision-making (Grudin & Poltrock, 1997).

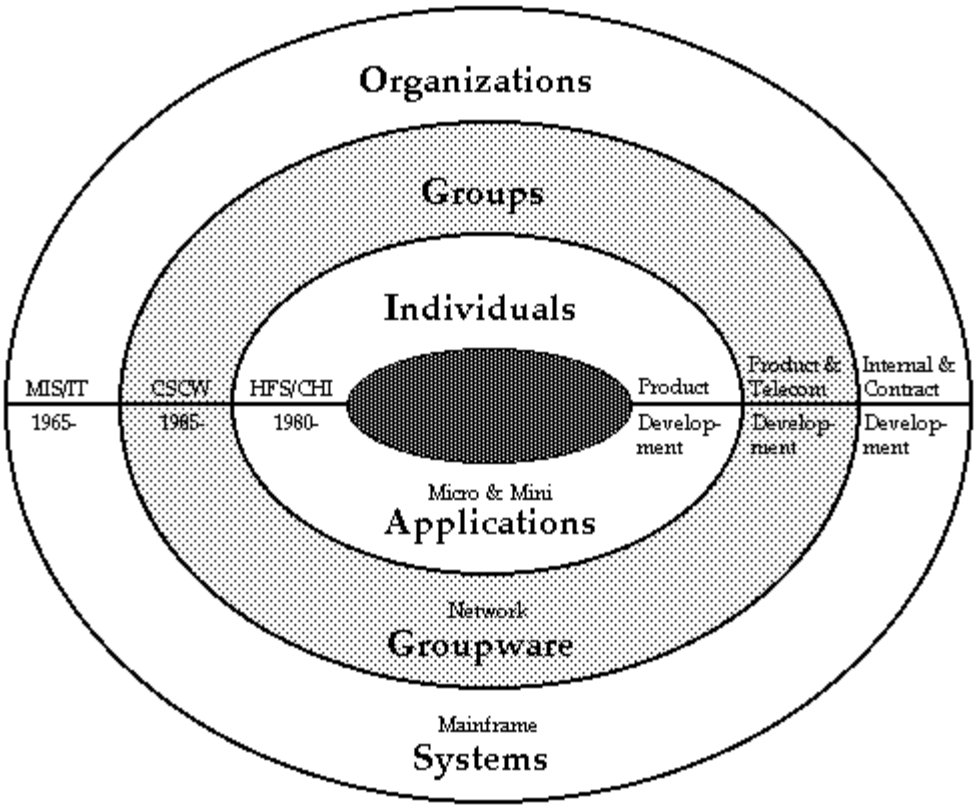


Figure 2.5 Three Rings of Software Development (Grudin, 1994)

Indeed, email, audio conferencing, synchronous instant messaging, video conferencing, electronic polls, and asynchronous bulletin boards are some of the many CTs that have been developed during the 1980s to 1990s. However, in recent years, a new wave of CTs has cascaded into our world. Newer breeds of CT include emerging electronic tools such as blogs (e.g. WordPress, Blogger), wikis (e.g. PBWorks, Wetpaint), online word processors (e.g. Google Docs, Zoho Writer), microblogs (e.g. Twitter, Plurk), social networking sites (e.g. Facebook, Linked In), and virtual worlds (e.g. Second Life, Kaneva).

The invention of these new breeds of CT is the result of the consumerism of IT where individuals can easily afford personal computers as well as Web 2.0 trends such as co-participation (O'Reilly, 2007). Web 2.0 concepts were first delineated by O'Reilly in 2004 to differentiate between new Internet concepts and earlier Web 1.0 concepts (O'Reilly, 2007). According to O' Reilly (2007), applications which embed Web 2.0 concepts are services rather than products, have control over unique, hard-to-recreate data sources that get richer as more people use them, encourage co-participation of users, harness collective intelligence,

and have lightweight user interfaces. Whereas Web 1.0 made it easier to find connected information, Web 2.0 is heralded as the social Web, as content is easily produced and presented by users.

This new wave of CT is usually inexpensive (or even free) and developed open-sourced. They tend to be simple web-based applications which allow groups to easily make use of them to share and create information (Johnson, Levine, & Smith, 2008). For instance, Pmwiki, is a wiki software that was released using a GNU General Public License by Patrick Michaud (www.pmwiki.org). It has been used by many groups including corporate project teams, special interest groups and academic project groups.

Based on this background of CT, what exactly is CT? CT has been defined generally as "a variety of electronic tools used by members of groups to communicate with each other, coordinate activities and execute tasks." (Carte & Chidambaram, 2004, p. 450). Some other researchers have viewed CTs as instrumental to learning. Based on educational theories, Roschelle (1992) defines a CT is a "tool that enables individuals to jointly engage in active production of shared knowledge. " (p. 40). Other researchers have opted for a differentiation between CT designed for education and CT that allows for collaboration in general. Lipponen and Lallimo (2004) term the former CT while the latter is known as collaboratively usable applications.

Any technology can potentially be used for collaboration, for instance, two individuals that are sharing a computer to write a report. The computer by itself provides a shared workspace for the individuals to collaborate. However, this is too broad a conceptualization and would mean that any device that can be physically shared would be a CT. Neither should a CT be specific to any content domain as this would imply a narrow field of collaboration. Thus, this thesis aligns itself with the broader definition of CT, that is, "electronic tools that allow group members to work jointly together". This definition encompasses various types of technologies in which each group member can communicate electronically with others to complete tasks.

2.3.1 CT and Group Effectiveness

With the advent of CT use in organizations, group effectiveness research took on another dimension. This can be seen in the addition of the technology category to group effectiveness models. A key CT topic of interest was the GSS and many studies examined how GSS differed from face-to-face groups (Dennis & Garfield, 2003; Fjermestad, 2004). For instance, Nunamaker et al. (1991) developed a research model that examined inputs in terms of group, task, context and GSS, the processes of process losses and gains, as well as the outputs of meeting outcome. Similar to the previous studies described in Section 2.1.3, the research is approached with an I-P-O model.

Fjermestad (1998) performed an extensive review of the group effectiveness studies and developed a theoretical framework to analyze GSS (Figure 2.6). The research conceives four categories of inputs: technology, group, task and context. Two overarching processes termed as intervening factors and adaptation factors are also proposed. Intervening factors refer to a set of conditions originating from the context of GSS sessions and include methods and group member perceptions. These represent covariates, moderators or even dependent variables in research.

Adaptation factors refer to the interaction processes of the group and three processes are denoted - the group adaptation process (e.g. structuration, participation), process gains and losses (e.g. synergy, social loafing), and intermediate role outcomes (e.g. role assumptions and values). These are the typical processes that have been examined by past research. Lastly, the outputs of the framework are the result of the interplay of the process factors with the input and contextual factors. Five outcomes are highlighted: consensus (e.g. decision agreement), efficiency (e.g. decision time), effectiveness (e.g. decision quality), satisfaction (e.g. decision satisfaction), and usability of the system (e.g. system utilization).

Fjermestad and Hiltz (1998) subsequently performed an assessment of 200 studies and compared between contextual factors and outcome factors. The results show no significant

differences between face-to-face and GSS groups. However, GSS use was found more effective with idea generation tasks, large groups, and on more complex problems. Although the study summed up the number of process variables used, it did not provide further analysis on the outcomes of process variables.

Baltes et al. (2002) conducted a meta-analysis of 27 studies comparing between face-to-face teams and CT-enabled teams. The findings reveal that CT-enabled teams were less effective (-.20), spent longer time to complete tasks (-.65), and had lower member satisfaction (-.25) than face-to-face teams. The research highlights that a possible intervention in CT-enabled teams is open communication such as by providing explicit statements valuing all comments of members. The research is notable as it is a detailed statistical examination of past research. It also provides theoretical directions in terms of the mediator, open communication. However, the research is limited to decision-making teams only and the relatively small sample sizes may bias the results.

As organizations entered into a more competitive environment, the need for distributed teams arose. Coupled with the decreasing costs of CT, this led to the emergence of the virtual team. Virtual teams comprise members working across locational, temporal, and relational boundaries supported by CT in varying degrees to accomplish a joint task (Martins, Gilson, & Maynard, 2004; Powell, Piccoli, & Ives, 2004).

Powell et al. (2004) in a review of virtual team research from the years 1991 to 2002 conceive that past research has examined two key processes of virtual teams: task and socio-emotional categories. The study analyzes the emergent states of the two processes. Task processes consist of communication, coordination and task-technology fit while socio-emotional processes refer to relationship building, cohesion and trust concerns. The review is also framed using an I-P-O approach with the inputs being design, culture, technical expertise, and training and the outputs of performance and satisfaction.

Theoretical framework for analyzing group support systems

INPUT	PROCESS		OUTPUT
CONTEXTUAL FACTORS	INTERVENING FACTORS	ADAPTATION FACTORS	OUTCOME FACTORS
TECHNOLOGY: . Task Support (Tools): Agenda, electronic brain storming, voting, cognitive feedback, etc. . Process Structures: Anonymity, time, proximity, settings, procedures, control & structure; e.g. sequential Vs parallel process; levels 1, 2, and or 3, structural features-restrictiveness, comprehensiveness, agenda setting NGT, DI, DA, facilitator, chauffeur, moderator. . Communications Mode: FtF, CMC, GSS, DSS, text, graphics, voice, image, sound, and video. . Design: Room configuration, interface, embeddability, extensibility, flexibility, functionality & usability. GROUP: . Group characteristics: Size and salience, ad-hoc, established. . Composition: Heterogeneity, organizational & job tenure, shared norms, member status, history & experience, subject type (student, MBA, professional, etc.). . Leadership: Formal leadership, style, attitude, skills, power, and organizational position. . Member characteristics: Attitudes, values, power, personal beliefs, age, sex, preferences, self confidence, skills demographics, personality traits, initial quality, & experience (systems & tasks). . Meeting structure: Clarity of objective, specific work norms. . Initial levels: Cohesiveness, task understanding, consensus, and agreement. . Group Structures: Styles of interacting, knowledge & experience with structures, perceptions of others knowledge. TASK: . Type: Generate, choose, negotiate, and execute; gain/loss . Characteristics: . Structure: Structured to unstructured . Equivocality: High to low . Analyzability: High to low . Complexity: High to low . Importance: High to low . Enjoy ability: High to low . Predictability: High to low . Source: Internal to external . Degree of task knowledge . Degree of agreement on values CONTEXT: . Environment: Competition, uncertainty, time pressure, evaluative tone. . Organizational: Information system, age, goals, reward structure, organizational size, etc. . Cultural: American, British, Chinese, Hawaiian, Singaporian, etc.	METHODS: . Experimental design . Task implementation . Session length . Number of sessions . Order (order of treatment or task) . Training: technology, group process and task SUMMARY VARIABLES RESULTANT COMMUNICATION DIMENSIONS: . Bandwidth . Media richness . Social presence GROUP MEMBER PERCEPTION & PROBLEM SOLVING: . Nature and utilization of task performance strategies . Level and utilization of member knowledge & skill . Level & coordination of member effort . Task: importance,visibility, understanding, & commitment . Individual: values, personal needs, level of interest, and degree of frustration . Psychological differences . Biases ORGANIZING CONCEPTS: . Information processing systems . Consensus generating systems . Behavior motivation & regulation OPERATING CONDITIONS . Modalities available . Changes in task, rewards, norms & division of labor	GROUP ADAPTATION PROCESS: Structuration . Social technology . Structural features . General spirit . Faithful/Ironic . Rules, resources- use, attitude, control, and consensus . Comfort, respect Process Variables . Participation . Consensus generating . Normative regulation . Effectiveness . Level of effort Process Issues . Diffusion of responsibility . Deindividuation . Pressure to consensus . Coordination PROCESS GAINS/LOSSES: Process Gains . Synergy, learning . Clarity, Choice shift Process Losses . Free riding . Evaluation apprehension . Attenuation blocking . Information overload . Flaming . Dominance INTERMEDIATE ROLE OUTCOMES . Role assumption by technology . Actual roles of participants Task-related & group-building: recorder, gatekeeper, follower, information/opinion seeker, information/opinion giver, proceduralist, motivator, explainer, evaluator . Values	CONSENSUS: . Decision agreement . Commitment EFFICIENCY MEASURES: . Decision time . Number of decision cycles . Time spent in activities . Time spent waiting for responses . Time to consensus EFFECTIVENESS MEASURES: . Communication . Number of comments . Idea Quality . Decision quality . Decision confidence . Process quality . Creativity/Innovation . Level of understanding . Task Focus . Depth of Evaluation . Commitment to results SATISFACTION MEASURES: . Participation . Cohesiveness . Conflict management . Influence . Confidence . Attitude . General satisfaction . Decision Satisfaction USABILITY MEASURES: . Learning time . Willingness to work together again . System utilization . Number of errors . Design Preference

Figure 2.6 Theoretical Framework for Analyzing GSS (Fjermestad & Hiltz, 1998)

The unique limitation of little or no face-to-face interaction in virtual teams surfaces the need for socio-emotional development as well as good communication. The review summarizes that socio-emotional research has focused mainly on improving relations among team members to build team identity and belongingness, and the specific issues of team cohesion and trust. Past research has also demonstrated empirical links between socio-emotional processes and performance outcomes.

Another important contribution of the research is the recognition of the importance of the communication process in virtual teams. Powell et al. (2004) states, “at the core of any virtual team process is communication” (p.11). Communication, be it in terms of type, frequency, etc., is the lifeline of a team. Although research has suggested several ways of improving communication, the phenomena in CT-enabled environments seem to be a particularly tricky area to examine. Limitations such as time delays, a lack of shared mental models and nonverbal communication seem to increase the difficulties of communication in CMC.

As can be seen from past research, the social aspect of the group is gaining in importance. Incidentally, the study of social or maintenance functions was common in the early days of group research, but this declined in the 1980s and 1990s (Liu, 2002), where the focus was on task behaviors. Recent developments have shown the utility of examining non-task functions (Powell, et al., 2004). In a sense, this shows a change from the dominant functional perspective to other perspectives or paradigms, notably the psychodynamic perspective.

In a subsequent review of virtual team research, Schiller and Mandviwalla (2007) focus on the theory use and development in virtual team research. This review concentrated on 45 articles that were published between 1990 and 2005. The authors adopt the I-P-O framework from Powell et al. (2004) and through an inductive process map 25 theories to the framework. This resulted in categories and sub-categories of inputs (members and context), processes (communication and social interaction), and outputs (task performance and effectiveness).

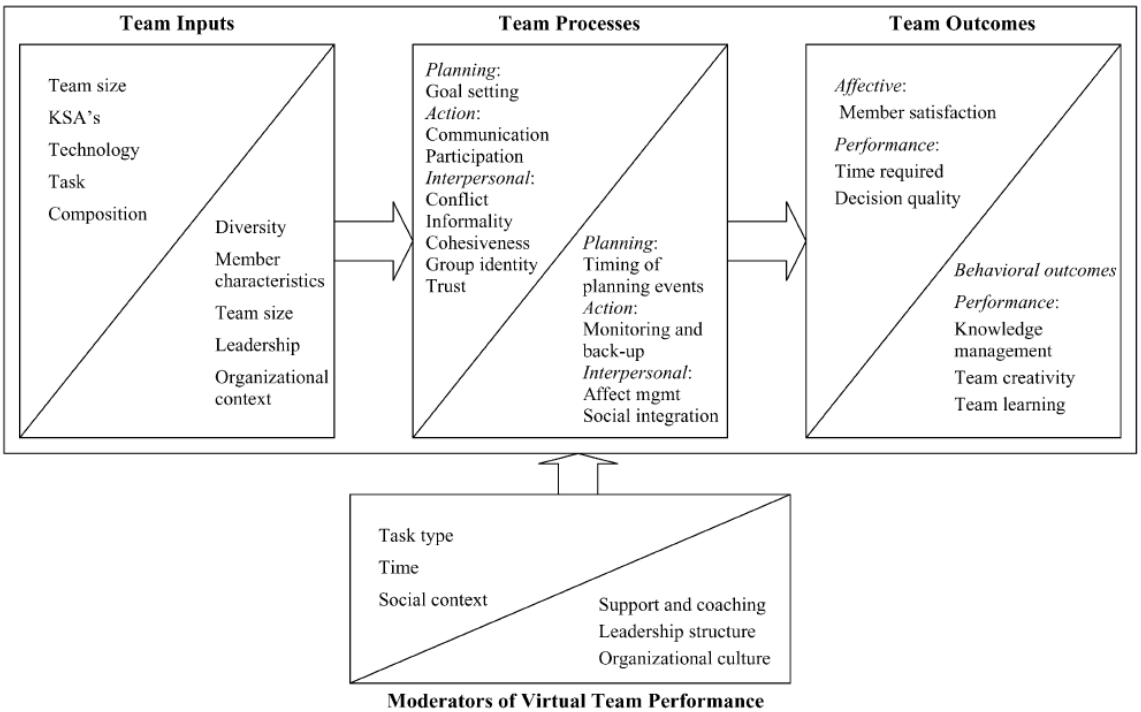
Additionally, the research develops a framework for selecting theories. This framework consists of seven criteria: objective, appropriateness, robustness, quality, structure, perspective, and IT artifact. The research claims that there has been no dominant theory in virtual team research. Theories utilized tend to emphasize behavior at the individual and group levels. The authors call for research to examine the virtual team phenomena from other paradigms and disciplines.

The IMOI is one such new paradigm of examining group effectiveness (Ilgen, et al., 2005). As described in Section 2.1.3, it broadens the approach of the traditional I-P-O model. Some headway has been made with the IMOI model, although research has been scarce. For instance, Algesheimer et al. (2011) studied virtual teams comprising of professional online gaming teams. The research proposed that team inputs, mainly in terms of the demographics (size, tenure, and heterogeneity) would affect group processes, namely the mediators, communication and cohesion. Two emergent states were investigated: strategic consensus (consisting of the constructs “desire to perform” and “through shared goals”) and joint intentions. Group processes would affect strategic consensus. In turn, strategic consensus would affect joint intentions. Joint intentions would then affect expected performance and actual performance. Finally, past performance was used as a feedback indicator in the model. Past performance was predicted to affect the processes and outputs of the model.

The research surveyed 606 teams and found general support for the hypotheses. One key contribution is the use of past performance as an input. The relationship between past performance and the group processes, emergent states, expected performance and actual performance was significant in the positive direction. It reinforces the validity of feedback indicators in the IMOI model. Overall, the study’s findings suggest the utility of a dynamic model to predict group effectiveness. However, a limitation of the study was that it examined online gaming teams, which are rather dissimilar to other organizational teams or learning groups.

Nevertheless, the majority of research on CT and group effectiveness has been investigated using the I-P-O approach. In another review of virtual team research, Martins et al. (2004) summarize 93 past studies and conceptualize an I-P-O model of virtual team functioning (Figure 2.7). Similar to the traditional I-P-O model, several inputs such as knowledge, skills and abilities (KSAs), technology and composition, are proposed to affect processes and outcomes. In addition, the research delineates several moderators of virtual team performance including task type and time.

The review classifies three types of processes: planning, action and interpersonal. The first pertains to processes that help to center the direction of the group. The second type of process refers to the dynamic and task-based activities that occur in the group while the third type corresponds to relationships among group members. The research also highlights several aspects of the model that need further study. This includes inputs such as member characteristics, interpersonal processes such as affect management and outputs such as team learning.



*Within each category of variables, those that have been examined in research on VTs are listed above, and those in need of future research are listed below, the diagonal.

Figure 2.7 I-P-O Model of Virtual Team Functioning (Martins, et al., 2004)

In sum, past literature on CT and group effectiveness has tended to follow an I-P-O approach. However, variations to this model have been documented but further research is needed. Additionally, the research has revealed inputs in terms of technology and human factors. These inputs can affect the effectiveness of groups (Fjermestad & Hiltz, 1998; Martins, et al., 2004). Technology's role is indeed important and the following section will proceed to provide an in-depth review of the characteristics of CT.

2.3.2 CT Characteristics

To further understand the role of CT in affecting group effectiveness, a decompositional view is adopted (Clark & Brennan, 1991; Daly-Jones, et al., 1998). The decompositional approach separates technology into fundamental parts. It enables the examination of characteristics of CT solely rather than the medium in general which has been called for in past research (Carte & Chidambaram, 2004; Nelson, 1990).

From a review of the extant research, three sets of literature surface regarding characteristics of CT. The first type of literature is rooted in media choice theories. These studies examine all types of media ranging from face-to-face to electronic media and identify the core capabilities of the media. The second type of literature is a broad characterization of traditional CT and includes CT taxonomies, categories and frameworks. Some characteristics have also been derived from a specific CT. The third set of literature refers solely to the new breed of CT. This review includes conceptual and empirical work based on Web 2.0 concepts and other emerging CTs. The review will culminate with the delineation of five salient CT characteristics for further study.

2.3.2.1 Media Characteristics according to Media Choice Theories

Media choice theories, also known as media trait theories, identify underlying dimensions of different communication media ranging from the face-to-face medium to virtual worlds. A key purpose of these theories is to provide individuals with the most suitable medium for the

communicated message i.e. a fit between technology and task. Two media trait theories are reviewed here – media richness theory and media synchronicity theory.

Media richness theory (Daft & Lengel, 1986) postulates that effective communication occurs when a medium has the capacity to allow senders and receivers to reach a common understanding. If no shared meaning develops, communication becomes ambiguous. In that regard, the richness of the media should match the degree of ambiguity in the communicated message to ensure good communication. Four characteristics determine the richness of the media: multiplicity of cues (visual, auditory, tactile), immediacy of feedback (seeking and giving), language variety (conversational, formal, technical), and personal focus (tailor the message to fit the recipient).

Face-to-face communication is considered the richest medium as it allows a high level of cues, high immediacy of feedback, many types of language styles and high personal focus. On the other hand, email is theorized as a lean medium as it has a low number of cues (only visual), low immediacy of feedback, and is suitable for precise and quantifiable information transfer. Table 2.1 which is adapted from Newberry (2001), Tan (2005), and Wagner & Schroeder (2010) illustrates the media characteristics of various media. Although empirical findings for this theory have been conflicting (Lee, 1994; Markus, 1994), the theory has identified valuable features to assess the different media (Wagner & Schroeder, 2010) and is an important theory for "individual-level rational choice explanation of behavior" (Markus, 1994, p.523).

Table 2.1 Media Characteristics According to Media Richness Theory

Medium	Multiplicity of cues	Immediacy of feedback	Language variety	Personal focus
Face-to-face	High	High	High	High
Videoconference	Medium	High	Medium	Medium
Synchronous audio	Low	High	Medium	Medium
Email	Low	Low	Medium	Low-Medium
Synchronous instant messaging	Low	High	Medium	Medium
Blog	Medium	Medium-High	Medium-High	Medium-High
Wiki	Low-Medium	Low-Medium	Medium-High	Low

Note: Adapted from Newberry (2001), Tan et al. (2005), and Wagner & Schroeder (2010)

The media synchronicity theory (Dennis & Valacich, 1999) is based on the media richness theory but extends the theory to focus on the ability of media to synchronize communication and collaboration processes in groups. This theory was subsequently refined to include Shannon and Weaver's (1949) theory on communication (Dennis, Fuller, & Valacich, 2008). The media synchronicity theory emphasizes the fit between media capabilities and the underlying communication processes. Five characteristics are conceptualized which relate to information processing and transmission capabilities: rehearsability (the degree that the message can be fine-tuned when sent), reprocessability (the degree that the message can be re-examined when received), velocity (speed of message transmission; similar to immediacy of feedback), parallelism (number of simultaneous transmissions), and symbol sets (number of ways information is encoded; similar to multiplicity of cues).

Table 2.2 which is adapted from Dennis (2008), Tan et al. (2005), and Wagner (2010) illustrates the media characteristics of selected media. The face-to-face medium has the highest capability for information transmission i.e. in terms of velocity, parallelism and symbol sets, but a low capacity for information processing (rehearsability and reprocessability). In contrast, email has high rehearsability, reprocessability and parallelism and lower degrees of velocity and symbol sets. The theory posits that no single media is perfect for any task, and a combination of media to balance strengths and weaknesses of each media can help communicators reach shared understanding.

Due to its infancy, the theory has only been tested in limited areas. There have been direct examinations (Mohan, Kumar, & Benbunan-Fich, 2009) and indirect studies that discuss the theory as a possible reason for their empirical findings (Zhu, Benbasat, & Jiang, 2010). For instance, Mohan et al. (2009) examine parallelism, velocity and reprocessability in a case study of software developers and found that choice of media depended on developer's perceptions of media's ability to support a particular characteristic. A body of evidence for the theory is still wanting.

Table 2.2 Media Characteristics According to Media Synchronicity Theory

Medium	Rehearsability	Reprocessability	Velocity	Parallelism	Symbol sets
Face-to-face	Low	Low	High	Medium	High
Videoconference	Low	Low	High	Medium	Medium
Synchronous audio	Low	Low	High	Low	Low
Email	High	High	Low-Medium	High	Low-Medium
Synchronous instant messaging	Medium	Medium-High	Medium-High	Low-Medium	Low-Medium
Blog	High	High	Medium-High	High	Medium-High
Wiki	High	High	Low-Medium	High	Low-Medium

Note: Adapted from Dennis (2008), Tan et al. (2005), and Wagner & Schroeder (2010)

2.3.2.2 General Characteristics of CT

Several taxonomies and frameworks have been employed to categorize CT. The earliest and most basic classification scheme is the time-space matrix. This characterizes CT in terms of synchronicity and place requirements. One of the earliest 2 by 2 conceptualizations was devised by Johansen (1988). This was subsequently modified by Nunamaker (1991) with the addition of group size, and DeSanctis and Gallupe (1987) which added the dimension of task type.

Grudin & Poltrock (1997) added another dimension to the matrix by considering the predictability of when and where CT was utilized. For instance, the authors classify email to be under the different but predictable time and place category as email can be read at various times but it would be expected to be read within a few days, and it can also be read at different places, but typically at the office or at home. On the other hand, workflow management systems are designated under the different and unpredictable time and place category. These workflow management systems can be accessed at different times and at different frequencies, ranging from highly often or intensive usage to limited use. They can also be utilized in different places and one is unable to predict where it will be employed.

Benbunan-Fich (2002) extends the time-space matrix for the learning context. The research adds the dimension of pedagogy i.e. the objectivist versus constructivist approach, to the model. For instance, in the different time, different place category for the objectivist model,

the example is video-streaming of prerecorded lectures while the example for the constructivist model is electronic bulletin boards.

Munkvold (2003) updated the matrix with newer types of CTs with an emphasis on the organization. Whereas previous research categorized a CT in only one category, Munkvold argues that CTs can be put in more than one category as CTs can support interaction in more than one mode. For instance, the author proposes that electronic bulletin boards can be used at the same place and at different places, both at different times.

Although the time-space matrix has been a popular classification scheme, it has not been especially useful for implementation in organizations (Grudin & Poltrock, 1997; Munkvold, 2003). Moreover, many CTs used in organizations contain too many overlapping characteristics. Another somewhat useful classification of CT characteristics is by function. Grudin & Poltrock (1997) posit three activities of CT: communication, collaboration, and coordination. The authors explain that even with overlapping functions, a CT still has its predominant function. Communication involves the exchange of information over CT such as video conferencing and email. Collaboration involves the creation of a virtual artifact that becomes the output and makes use of shared information spaces such as multi-user whiteboards and electronic bulletin boards. Coordination features help manage the interaction between participants and include calendar systems and workflow management systems.

Zigurs and Munkvold (2006) outline five functions of CT: communication, information-sharing, process-support, coordination and integrated technologies. Communication and coordination CTs are similar to the earlier classification defined in Grudin & Poltrock (1997). The earlier collaboration component is divided into information-sharing and process-support functions. Information-sharing refers to CT that produces and manipulates information objects and interaction spaces such as document management system and electronic bulletin boards. Process-support functions refer to CT that supports meetings namely GDSS. This functional typology also adds another category, integrated CT for CT that cuts across the

other four functional categories. Examples include collaboration product suites and integrated team support technology.

Besides the functional typology, CT has also been viewed as a bundle of capabilities (Carte & Chidambaram, 2004). Carte & Chidambaram (2004) organize characteristics of CT into enabling and disabling technology, each consisting of bundles of core capabilities, an encompassing generation of technology with similar capabilities. Enabling technology has features which enhance communication and collaboration in the group. Three such additive capabilities are defined: coordination support (which facilitate schedules of people and tasks), electronic trail (which provide a database of work information), and enhanced capabilities (which help in decision-making). On the other hand, capabilities that prevent certain disruptive communication are termed disabling technology. Three reductive capabilities are identified: visual anonymity (which prevents recognition), equality of participation (which reduces sequential turn-taking), and asynchronous communication (which restricts immediate feedback).

One of the key focuses of CT research is on GSSs. Tyran and Shephard (2001) highlight three support features in GSS: anonymity, parallel communication, and process structure. GSSs provide anonymity as the identity of communicating members is unknown to other members. Parallel communication refers to group members being able to type messages all at the same time. Process structure pertains to the rules and protocols used to guide the participation of group members. This can be in terms of the content, pattern or timing of communication.

DeSanctis & Gallupe (1987) provide another conceptualization of GSS. In a pioneer study, they identified three overarching characteristics of GSS:

1. Level of support

   This was divided into three levels. Level 1 supported communication and included features such as voting and comment recording. Level 2 features were more advanced; these helped users make decisions that would be hard for them to perform

own their own such as multi-criteria decision making. Level 3 features refer to automated facilitation and expert systems that recommend solutions to the group.

2. Restrictiveness of the GSS

This refers to the degree of freedom the user has in applying the technology. Some GSSs are more flexible than others, allowing a variety of uses, while other GSSs must be used in a certain manner.

3. The spirit of the GSS

This relates to the general intent regarding the values and goals guiding the design of features in the GSS (DeSanctis & Poole, 1994).

In another notable study, Zigurs and Buckland (Zigurs & Buckland, 1998) reviewed at least 11 GSS studies and surmised three essential characteristics: communication support, process structuring and information processing. This is described in Table 2.3, adapted from Zigurs and Buckland (1998).

Table 2.3 Characteristics of GSS

Characteristic	Description	Examples of elements
Communication support	Any feature that helps group members to communicate with each other	Simultaneous input, synchronous or asynchronous communication
Process structuring	Any feature that facilitates ways in which the group can record the process of interaction	Agenda setting, human and artificial intelligence facilitation
Information processing	Any feature that manages the information that is produced by the group	Gathering information, structuring information

As can be seen, many features of GSS have been suggested in the extant literature. Fjermestad (1998) reviewed 16 GSS models and frameworks and developed four technology characteristics. They are task support (tools), process structures, communication mode and design. Tools refer to the specific applications that the technology has such as type of electronic brain storming and voting. Process structures are features that affect the decision process and include anonymity, proximity, settings, procedures, and structural features such as restrictiveness, comprehensiveness, and the use of a facilitator. Communication mode is the medium used in the technology and ranges from face-to-face, computer-mediated

communication, to video capabilities of the technology. Lastly, design consists of the configuration of the decision room, the interface, embeddability, extensibility, and flexibility of the software and usability of the entire system.

Zigurs and Munkvold (2006) review that in the last 30 years there have been five CT eras: teleconferencing, group support, enterprise, virtuality, with the current time being the ubiquity era. The teleconferencing era produced the typologies of CTs. The group support era provided many studies on GSS and their respective characteristics. Next, the enterprise era centered on the implementation of CT in the workplace. There was no particular focus on a specific CT, but rather how CT could be employed in the organization. As for the virtuality era, studies highlighted a broad range of CT that could be used for virtual teams. Once again, no particular CT was spotlighted on. Finally, the ubiquity era has provided a host of new CTs. This latest era was influenced by Web 2.0 concepts as well as technology breakthroughs. There has been some research on these new breeds of CT, especially the wiki, which is one of the first CT developed during the current era. The next section will focus on characteristics of these new breeds of CTs.

2.3.2.3 Web 2.0 and Characteristics of New Breeds of CT

Web 2.0 is a huge amalgamation of ideas and principles. Kim et al. (2009) attempt to provide some structure to the concept by dividing the Web 2.0 paradigm into four hierarchical layers. The framework is illustrated in Figure 2.8. Using a technology push/demand pull theory, the work explains that there has been a push from the IT developers to create such new technology; this is denoted by the technology layer. The Web 2.0 technology layer lists the enabling technologies and technical concepts e.g. AJAX, Rich Internet Applications, that are the building blocks for the next layer. The next layer is the Web 2.0 principle layer which represents “common fundamental characteristics observed from current Web 2.0 platforms unique from traditional applications” (Kim, et al., 2009, p. 661). These include the characteristics of participation, collaboration, social networking, and rich user experience.

Sitting on top of the principle layer are the actual Web 2.0 applications themselves, this is called the Web 2.0 Application Layer. These range from social networking sites (e.g. Facebook, Orkut), to sharing site (e.g. YouTube, Flickr), blogs (e.g. radar.orilly.com) and social bookmarking (e.g. Diigo, Delicious). These applications are pulled by the market in order to solve various needs such as usability needs, sharing needs, online business needs and so on. This final layer is known as the Web 2.0 Driver layer representing the various motivators for the use of these tools.

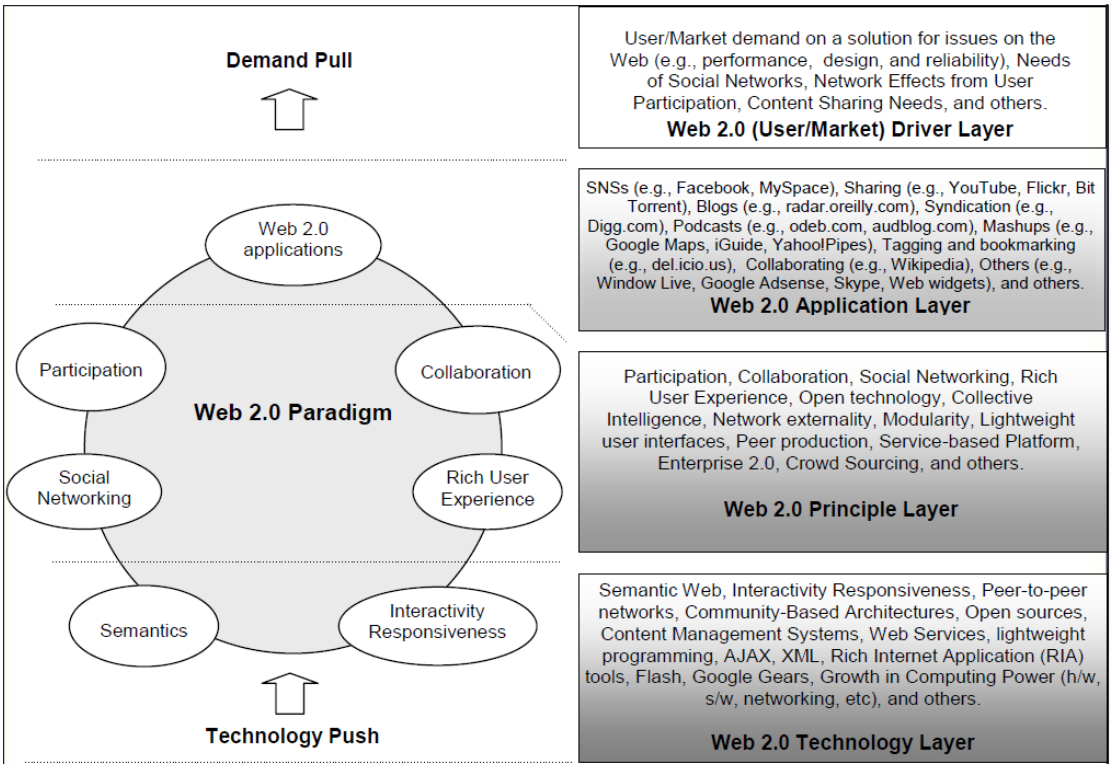


Figure 2.8 Conceptual Framework of Web 2.0 Paradigm (Kim, et al., 2009)

With a new breed of CT prompted by the influx of Web 2.0 principles and technologies, several CT characteristics have been conceptualized. Anderson (2007) elaborates that these new CT focus on individual production and user generated content (individuals as both producers and users of information), harnessing the power of the crowd (aggregating mass data collected for insight), an architecture of participation (systems that have been designed to encourage and support users in contributing to them), network effects (the increase in value of the network when more people use it), and openness (referring to the control, access and rights of digital content).

Parameswaran and Whinston (2007) define these CT within the sphere of social computing. They identify common traits of these CTs including: decentralization(no central control of the system), dynamic information spaces (units of content are continually undergoing change and refinement), flexible structure (structure of content is minimal and can be organized in any way), fluid boundaries (collaborating individuals can cross organizational boundaries), and lightweight development (built using relatively easy-to-use and predominantly open-source computing tools such as Ajax, Perl, Ruby on Rails, and MySQL).

While the earlier framework was conceptually constructed, other research has also utilized empirical methodology to formulate CT characteristics. Using multidimensional scaling methods, Ali-Hassan and Nevo (2009) discovered three underlying dimensions of Web 2.0 technologies. These apply to the newer CT as well. The research was set in the context of social computing in the organization and involved a survey with international respondents. The final 144 respondents accounted for a 16% response rate. Based on the analysis, three dimensions were found. They are the social aspect which ranges from connecting information to connecting people, the purpose of the tool which could be hedonic or utilitarian, and the type of content supported i.e. conveyance or convergence. However, this work is not specific to CT and does not compare between older and newer breeds of CT.

Similar to the difference between Web 1.0 and Web 2.0 as described by O' Reilly (2007), a distinction is drawn between traditional CT such as email, videoconferencing and electronic bulletin boards and the newer breed of CT such as wikis, blogs and social networking sites. Turban, Liang and Wu (2011) term these new set of tools collaboration 2.0 while the earlier set of tools are referred to as collaboration 1.0. The research provides a comparison of the characteristics of the two sets of CTs which is illustrated in Table 2.4.

Table 2.4 Comparing Collaboration 1.0 and 2.0 adapted from Turban et al. (2011)

Area	Collaboration 1.0	Collaboration 2.0
Context	Enterprise controlled	User generated, flexible, and dynamic
Ease of use	Can be complex	Very user friendly
Cost	Can be very high	Very low
Platform	Propriety	Open source, flexible
Focus	Transaction support	Interaction-based
Interactivity level	Low	High
Collaboration nature	Structured, initiated by the company	Unstructured, initiated by users
Add-on application	Created by the enterprise	Can created easily by users
Channel for information push and sharing	E-mail, text messages	RSS feeds, Microblogging (e.g. Twitter)
Flow of information	Structured, top down	Unstructured, bottom up
Context tagging for search	Usually not done, or done for search engine optimization	Done by users, Folksonomy
Combining applications	Require complex programming	Easily done with mashups
External expert contacts	E-mail, proprietary contacts	Social networks, mass collaboration, forums
Supporting environments	Extranet VANs, Intranets	Social networks, Intranet, virtual worlds and infrastructure
Flexibility	Low	High
Software for collaboration	Structured, may not be modified; must be installed	Unstructured; often no need to install

The wiki is one of the pioneers of the new breed of CT. Wiki characteristics may provide some guidance and direction for the overall characteristics of CT. Ebersbach et al. (2008) provide five properties in wikis. These are in terms of editing, links, history, recent changes and search functions. Editing refers to wikis being editable by any user and employing the same basic page editing functions such as text editing and image, table, list, hyperlink and file insertion. As for links, each page on the wiki can be hyperlinked to other pages in the wiki as well as external webpages. The history capability refers to the ability for the wiki to record all previous versions or modifications of any single page. This allows the editing process of a page to be tracked. Recent changes refer to the new modifications to the wiki pages that have occurred based on a predefined time period. Lastly, the search function is simply a text or title search in the wiki pages.

Ward Cunningham, the founder of the wiki, describes 11 design principles of the wiki (Leuf & Cunningham, 2001)

1. Open - Should a page be found to be incomplete or poorly organized, any reader can edit it as they see fit.

2. Incremental - Pages can cite other pages, including pages that have not been written yet.
3. Organic - The structure and text content of the site are open to editing and evolution.
4. Mundane - A small number of (irregular) text conventions will provide access to the most useful page markup.
5. Universal - The mechanisms of editing and organizing are the same as those of writing, so that any writer is automatically an editor and organizer.
6. Overt - The formatted (and printed) output will suggest the input required to reproduce it.
7. Unified - Page names will be drawn from a flat space so that no additional context is required to interpret them.
8. Precise - Pages will be titled with sufficient precision to avoid most name clashes, typically by forming noun phrases.
9. Tolerant - Interpretable (even if undesirable) behavior is preferred to error messages.
10. Observable - Activity within the site can be watched and reviewed by any other visitor to the site.
11. Convergent - Duplication can be discouraged or removed by finding and citing similar or related content.

Similarly, other research has emphasized two key features of the wiki: accessibility and reviewability (Choy & Ng, 2007; Hester, 2010; Kane & Fichman, 2009; Schwartz, Clark, Cossarin, & Rudolph, 2004). Kane (2009) terms these two characteristics “open editing” and “edit preservation” respectively. Firstly, users access the wiki via a browser with an Internet connection; no special software is required. Moreover, the wiki allows viewers to become editors and contribute to the content. Anyone can potentially edit the content on a wiki. Secondly, reviewability is the ability of the wiki to save all changes of the content. Users can view a revision history of past changes and be updated of new content. Due to these revision and history features, users can easily recover deleted or previously edited content or roll-back to an earlier version of the page.

In addition, Wagner and Schroeder (2010) highlight that wikis have very similar functionality to email except for the characteristic of refactoring. Refactoring refers to the ability for communicated messages to be edited by users and as a result change or evolve in its meaning. This implies that the message is not just communicated passively to receivers but the receivers are able to adjust the message and enrich the communicated content.

These studies have revealed many different types of CT characteristics, some of which have different levels of granularity. However, CT characteristics which are too specific and fine-

grained cannot serve as useful characteristics of CT for further analysis and research. Based on the literature reviewed, the thesis summarizes five CT characteristics that apply to both traditional CT and newer breeds of CT (Carte & Chidambaram, 2004; DeSanctis & Gallupe, 1987; Fjermestad & Hiltz, 1998; Kreijns, et al., 2002). While these characteristics do not encompass every aspect of CT, they represent key areas of CT. These five overarching characteristics of CT are communication support, connectivity, information structure, sociability, and visibility. Table 2.5 provides a summary of CT characteristics from the literature with respective elaborations for traditional CT and newer CT.

Communication support refers to ways to facilitate and enhance the communication of group members. For traditional CT, these tend to be specific tools and fine-grained functions such as simultaneous input, anonymous input, group display, voting tools, archival record and group display (DeSanctis & Gallupe, 1987; Wheeler, et al., 1999). In terms of media synchronicity theory, communication support tends to have low rehearsability and reprocessability. On the other hand, newer CT seems to support communication more generally. Most tools preserve discussion records which provide high rehearsability and reprocessability. This gives individuals the ability to communicate at their own convenience and remain in contact with their group. The archival record, especially versions of the record, can facilitate group memory (Parameswaran & Whinston, 2007).

Connectivity describes the ability of the technology to provide links to other individuals, networks and communities. Traditional CTs are focused on the connection of people to information within a group (Nunamaker, et al., 1991; Zigurs & Munkvold, 2006). They are also typically standalone. On the other hand, newer CT facilitates the connection of users among the group and the wider community (Ali-Hassan & Nevo, 2009; Anderson, 2007). For instance, connectedness is enhanced between a group and resources via instant hyperlinks in blogs and social networking sites. Community formation is also emphasized using newer CT.

Information structure refers to the display of information in the CT. For traditional CT, information sharing is based on rigid information structures. For instance, GSS uses specialized pre-defined templates to gather, aggregate, structure and evaluate information (Grudin & Poltrock, 1997; Zigurs & Buckland, 1998). In contrast, newer CT has a flexible information structure which allows continuous modification (Kim, et al., 2009; Turban, et al., 2011). The simple and minimal information space gives rise to many ways of using it. For instance, the wiki allows individuals to refine content in any way (Leuf & Cunningham, 2001).

Sociability, simply defined, is the capability of technology for formal and informal conversations. Earlier CT was focused on formal conversations, the task at hand. These earlier CT adopted a task-oriented paradigm (Zigurs & Munkvold, 2006). Carte and Chidambaram (2004) suggest that sociability was weak as traditional CT limited identification. In contrast, newer CT has a twofold agenda on both the task and the non-task, which is the social aspect (O'Reilly, 2007; Parameswaran & Whinston, 2007). Research suggests that the sociability feature of such technologies strongly augment learner-centered instruction due to support for informal conversations, social feedback, social networks, and relationship among individuals (Boyd, 2007; Kim, et al., 2009; Schroeder, Minocha, & Schneider, 2010).

Visibility refers to the private or public access modes of the CT. Users using traditional CT are usually private. Communication is within a closed group and could even be difficult for others to access (Nunamaker, et al., 1991; Turban, et al., 2011). In contrast, newer CT is typically open and public (Parameswaran & Whinston, 2007). It is open in the sense that they could encourage feedback and participation not just for the group performing the task, but also to other members of the public through voting and comments for example. Cunningham uses the term observable to describe a similar concept (Leuf & Cunningham, 2001). Newer CT is typically freely accessibly on the Internet and they encourage user-generated entries. Traditional CT can be metaphorically described as walled gardens as they operate within the

confines of the organization's network and in the purview of administrators (McLoughlin & Lee, 2007). On the other hand, newer CT can be seen as public playgrounds in which any interested user can participate in, while administrators generally have less control.

Table 2.5 Characteristics of Traditional CT and Newer CT

Characteristic	Traditional CT	Literature	Newer CT	Literature
Communication support	Specific functions such as voting, comment recording, anonymous input, archival record and group display.	DeSanctis & Gallupe (1987), Wheeler et al. (1999), Zigurs & Buckland (1998)	General functions such as versioning, archival record. High rehearsability and reprocessability.	Parameswaran (2007), Wagner and Schroeder (2010)
Connectivity	Low. Standalone.	Nunamaker et al. (1991), Zigurs (2006).	High. Well-connected. Potential for community formation.	Anderson (2007), Ali-Hassan and Nevo (2009)
Information structure	Well defined; typically pre-defined templates.	Zigurs & Buckland (1998), Grudin & Poltrock (1997)	Flexible and minimal	Leuf & Cunningham, (2001), Parameswaran & Whinston (2007)
Sociability	Low. Limited.	Carte & Chidambaram (2004)	High. Allows formal and informal conversations.	Boyd (2007), Kim et al.(2009)
Visibility	Low. Typically closed and private.	Nunamaker et al. (1991), Turban et al. (2011)	Typically open and public. At times a mixture of private and public access.	Leuf & Cunningham (2001), McLoughlin & Lee (2007), Anderson (2007)

2.4 Facilitating Learning Outcomes with CT

CTs can be used by corporations and educational institutes for learning. In education, CTs have been used formally by online and blended educational programs e.g. CoWeb at the Georgia Institute of Technology and informally by students e.g. openstudy.com. In this section, extant research on CT effectiveness that includes frameworks and meta-analyses will be reviewed. These are part of the body of knowledge of learning effectiveness and serve as guides for theoretical development. Next, the thesis will focus on the effectiveness of using the new breeds of CT for learning and conclude with research directions.

2.4.1 CT and Learning Effectiveness Research

CT has been adopted in several ways for group learning such as a shared workspace for collaborative writing (Lowry & Nunamaker, 2003), online group discussions (Blau & Barak, 2009) and a virtual learning environment (Johnson, Suriya, Yoon, Berrett, & Fleur, 2002). There has been substantial literature examining how CT has facilitated learning outcomes (Alavi & Leidner, 2001; Arts, et al., 2002; Eom, Wen, & Ashill, 2006; Gomez, et al., 2010; Prinsen, Volman, & Terwel, 2007). Many of these studies have identified factors that affect CT effectiveness Prinsen (Piccoli, et al., 2001; Prinsen, et al., 2007).

One of the first studies to identify these characteristics was a study by Piccoli et al. (2001) that conceptualized a learning effectiveness framework. The research examined CT in terms of a virtual learning environment (VLE), which is defined in terms of time, place, space, interaction and control features. In this landmark study, the research identified two dimensions of learning effectiveness, the human and design dimensions, which serve as antecedents for learning effectiveness. The human dimension consisted of learner and instructor characteristics while the design dimension comprised the learning model, technology, learner control, content and interaction. The framework is depicted in Figure 2.9.

The study proposes that human and design dimensions directly affect learning outcomes consisting of academic achievement, computer self-efficacy and satisfaction. An empirical study was carried out contrasting VLE learning with face-to-face instruction and the research found no significant differences for academic achievement. However, computer self-efficacy was enhanced with the use of VLE but satisfaction decreased. This study is noteworthy in that it outlines two key dimensions that affect learning outcomes. Unfortunately, the study was unable to test out the saliency of each antecedent of the two dimensions and called for further systematic research.

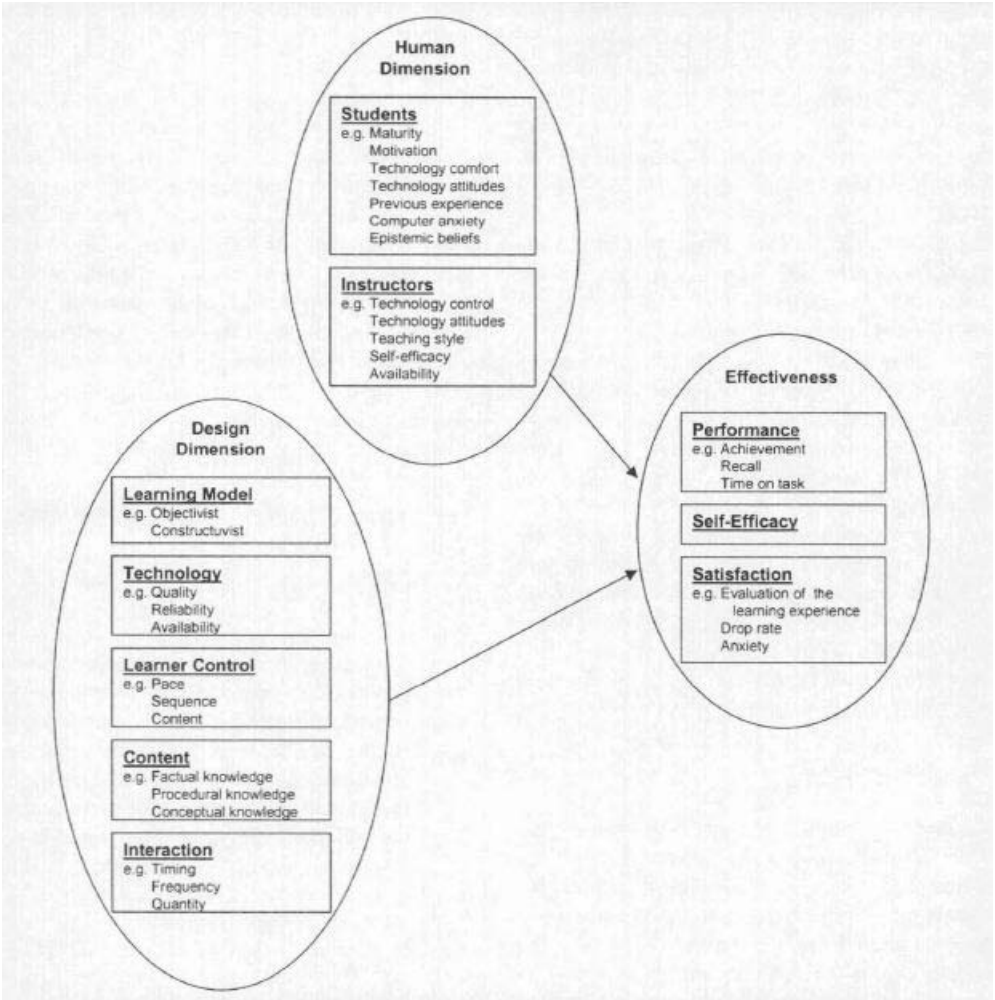


Figure 2.9 Dimensions and Antecedents of Virtual Learning Environment Effectiveness (Piccoli, et al., 2001)

Sharda et al. (2004) develop a theoretical framework consisting of outcomes and causal relationships for computer-supported collaborative learning requiring immersive presence systems (CSCLIP). CSCLIP is basically a distance learning technology that is a combination of immersive presence systems such as virtual reality, computer-supported learning systems such as VLE and pure collaborative systems such as GSS. The CSCLIP is designed for a laboratory setting which allows learners located at different laboratories to communicate and collaborate at the same time. This study extends the framework of Piccoli et al. (2001) by examining the psychomotor outcomes of learning which is pertinent to the CSCLIP environment as it involves a virtual reality component.

The CSCLIP framework conceptualized is based on collaborative learning theory, group theories, technology theories, presence theory and psychomotor theory. The casual

relationships in the framework predict that the CSCLIP environment will affect psychomotor, cognitive and affective learning outcomes. These learning outcomes mutually complement each other. In addition, human dimensions such as student, group and instructor characteristics moderate the relationship between the CSCLIP environment (design dimension) and learning outcomes. Figure 2.10 illustrates the framework.

In contrast to the earlier VLE framework which predicts a direct effect of the human and design factors on learning outcomes, this framework presents a moderating relationship between the two dimensions on learning outcomes. This suggests that the design dimension has a co-varying effect with the human dimension on learning outcomes. Learning outcomes can be different with different human factors with the same CT system. Yet, the research did not provide detailed hypotheses or test out the causal relations shown in the framework. Evidence for the interaction between human and design dimensions is warranted.

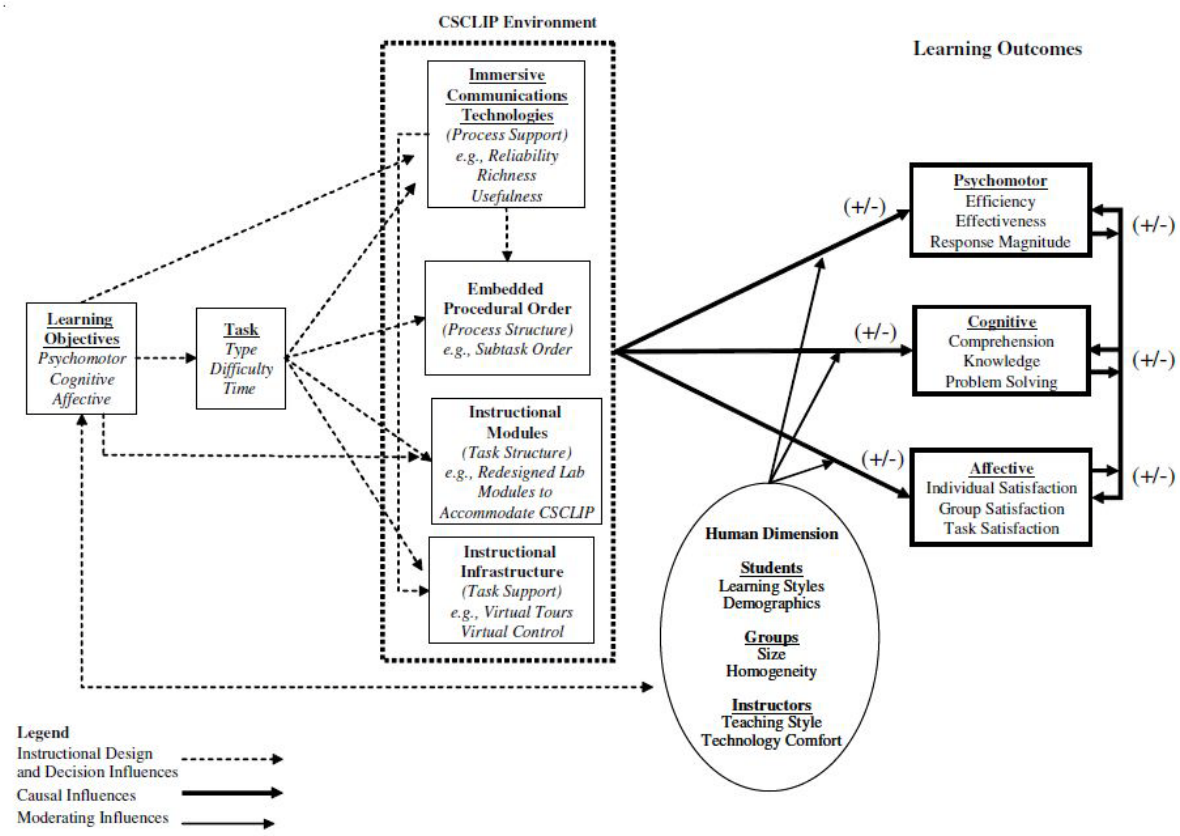


Figure 2.10 Framework for CSCLIP (Sharda, et al., 2004)

Brandon and Hollingshead (1999) reviewed past theories and research from the education, communication, IS, and psychology fields and proposed that three components are critical - collaboration, communication, and social context. The research underlines that learning outcomes arise from the collaborative development of shared meaning. In order to develop shared meaning, a substantial amount of communication is required. The research proposes that the social environment in which "collaboration and communication occur inherently influences learning" (p. 112).

Based on GSS research, Tyran and Shepherd (2001) develop a framework for learning effectiveness that comprises contextual factors, group process factors and outcome factors (Figure 2.11). The framework is based on a previous framework by Pinsonneault and Kraemer (1990) on electronic meeting processes and outcomes. Tyran and Shepherd (2001) add the factor of learning conditions to the existing contextual factors of person, situation, group, technology and task. As for group process, the research suggests four aspects that occur in learning groups: group learning, communication, interpersonal behavior and the structure imposed by the CT. Lastly, the framework proposes two areas of learning outcomes: academic performance and learning attitude.

This research is notable in that, in addition to group inputs, it summarizes a set of processes that can affect outcomes. Moreover, the research provides a detailed classification of contextual factors that can affect learning outcomes in groups. Nevertheless, the study was a conceptual undertaking and did not provide empirical justification for the relationships in the framework.

Benbunan-Fich and Hiltz (2003) investigate the process and outcomes of adopting an synchronous learning network system called Virtual Classroom over three years in 17 undergraduate Information Systems courses. The researchers hypothesized that the degree to which the system is perceived as improving access to learning (convenience and access to the professor) as well as experiences that are motivating, actively involving, and collaborative

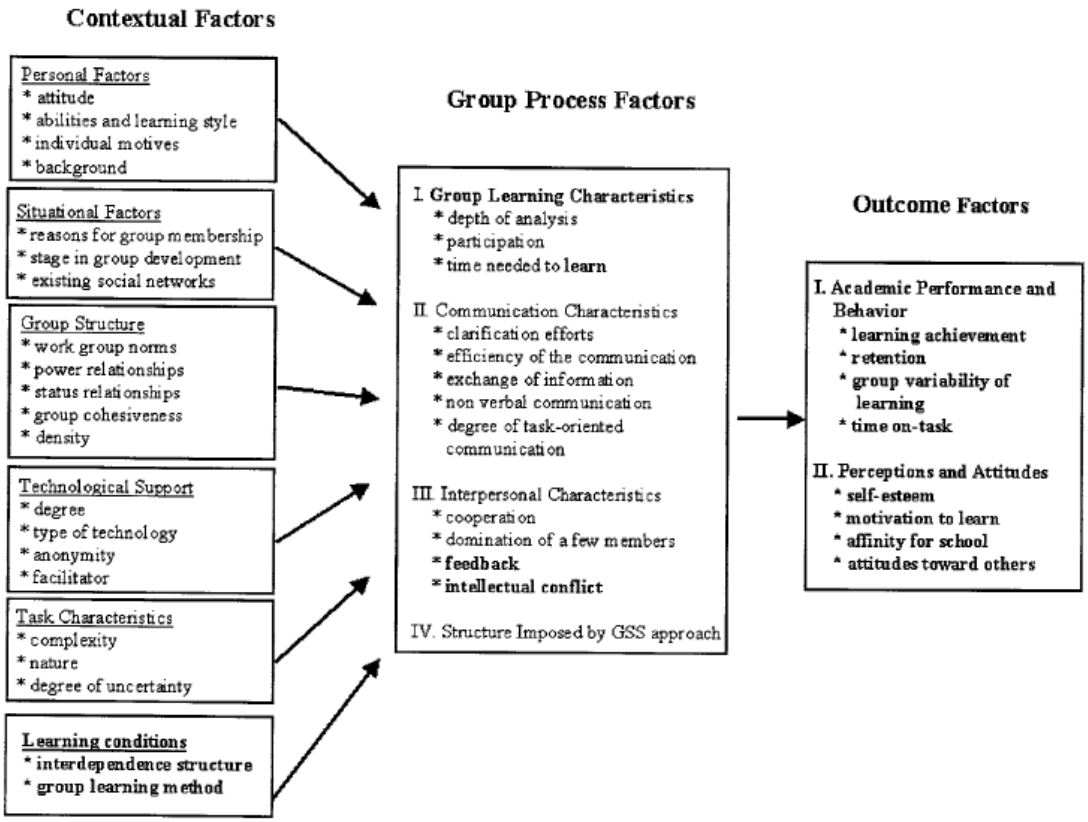


Figure 2.11 Framework for Analyzing the Impact of Collaborative Technology on Group Learning (Tyran & Shepherd, 2001)

rather than individual in nature, would affect perceived learning. More importantly, the effects on perceived learning would be moderated by technology, the course and learner characteristics. The study focused on technology in terms of three modes of course delivery: totally online via CT, traditional face-to-face, and a mix of traditional and online modes. Course was in terms of course type while learner characteristic was in terms of students' ability (i.e. grade-point average).

Based on survey responses of 842 students, the study found that mode of delivery did not affect perceived learning. In other words, purely online courses were rated similarly for learning outcomes as compared to the mixed mode and face-to-face mode. The research also found that group collaboration and access to professors was perceived to be highest in the mixed mode while convenience was valued the most in the purely online mode. In addition, course type and ability did not affect perceived learning.

This study provides empirical support for the effectiveness of CT. However, it did not explain the surprising result for student ability. It could be that students of different abilities rate that they have learned equally well since they are in a school environment where the purpose is to learn. Further research is needed to uncover other learner characteristics that could affect learning outcomes.

Chang and Lim (2005) perform a meta-analysis of 68 studies from 1990 to 2003 to investigate the effects of IT on learning outcomes. The research synthesizes that the degree of learning is moderated by learner characteristics (ability-grouping, study level, cultural background) and course characteristics (course content, instructor immediacy). Learning outcomes consists of actual learning such as academic achievement (increase in learning), knowledge retention (performance on follow-up exam), and task performance (producing higher quality and quantity of solutions in task); and perceived learning consisting of self-reported learning (students' perceptions of their learning process) and self-efficacy (degree to which learners feel capable of learning from a given method). Their research model is illustrated in Figure 2.12.

The meta-analysis compared between IT and non-IT learning environments and found that the availability of IT led to higher academic achievement (effect size of 0.51), knowledge retention (0.91), task performance (0.88), self-reported learning (0.60), and self-efficacy (0.89). Moreover, learner and course characteristics significantly moderated IT's effect on learning outcomes. For learner characteristics, homogeneously grouped learners (ability-grouping) had higher academic achievement and knowledge retention than heterogeneous grouped learners. School learners as compared to college students had higher task performance. Western cultures had higher self-reported learning and self-efficacy than eastern cultures. In terms of course characteristics, hard disciplines like mathematics, engineering and sciences had higher academic achievement with IT than soft disciplines such as literature and languages. Self-reported learning was larger for high instructor immediacy too. This paper has identified useful learner and course characteristics that affect learning outcomes.

However, the somewhat high effect sizes were not elaborated on and could be due to the inclusion of studies without a controlled design.

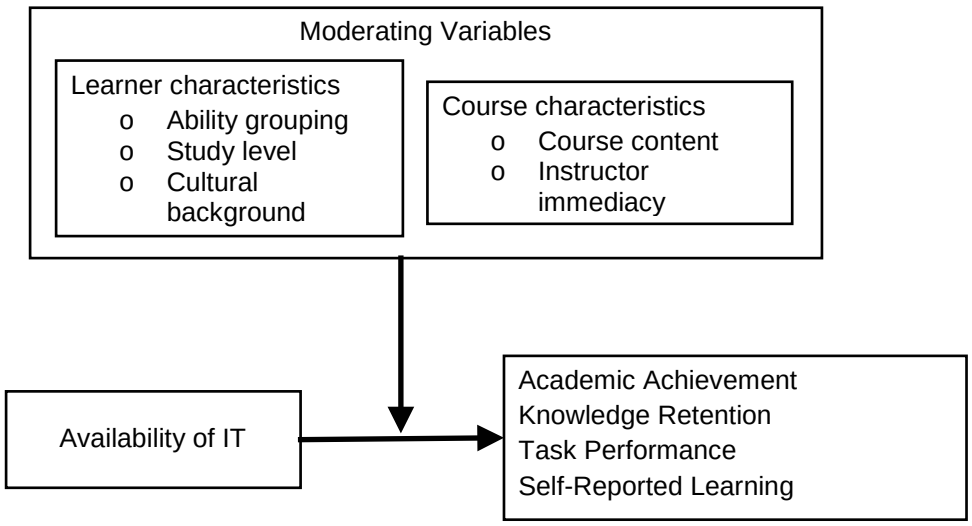


Figure 2.12 Research Model (Chang & Lim, 2005)

A recent meta-analysis which included relatively stringent selection criteria such as the use of a controlled design, was performed for 99 studies dating 1996 to 2008 (U.S. Department of Education, 2010). The research compared between face-to-face and purely online learning and found that online learners tended to perform better than face-to-face instruction (effect size of 0.05). Learners in blended learning (combination of online and face-to-face instruction) also performed better than face-to-face learning (0.35). In addition, the meta-analysis analyzed three groups of moderators: practice variables (aspects that are part of the intervention and can be altered), condition variables (status aspects that cannot be altered) and study method variables (aspects of the research design). Practice variables included pedagogy, media features and time on task. Condition variables included learner type and subject matter. Study method variables included sample size, type of knowledge tested, and study design.

As for the results of the moderators, only one practice variable and one study method variable affected the relationship between online learning and performance. Pedagogy, a practice variable, affected online learning effectiveness: learners from collaborative (0.25) and instructor-directed instruction (0.39) performed better than independent learners. Equivalence of instruction and curriculum, a study variable, moderated online learning effectiveness -

different or somewhat different instruction resulted in greater performance than identical or almost identical instruction (0.40).

The research also found that a practice variable, time taken, approached statistical significance at p=.06. More time spent in online than face-to-face learning had an effect size of 0.45 as compared to less or equal time spent in online than face-to-face learning. With this finding the researchers explain that the higher performance for online learning as compared to face-to-face learning could have arose due to the longer amount of time that learners spent on the task in online contexts. Nevertheless, the research is consistent with past research that has highlighted the value of collaborative learning. It has also summarized several technology and human characteristics that could affect learning outcomes.

In sum, extant literature has provided theoretical and empirical data on the effectiveness of CT in collaborative learning. Although some of the research has focused on technology in general and not particularly on CT (e.g. the two meta-analyses), they have hinted at an overall trend of the value of using CT. Moreover, these studies altogether have identified two key dimensions of CT and learning effectiveness: the technology and learner aspects, as well as several important processes. The above-mentioned studies have not specifically examined the new breed of CTs but mostly traditional CTs. The next section will review the effectiveness of the new breeds of CT.

2.4.2 New Breeds of CT and Learning Effectiveness Research

With the easy access and potential value of new breeds of CT, CTs have been widely adopted by learning groups. Schroeder et al. (2010) report that the top three CTs being adopted in education are the wiki, blog and social networking site. Wang (2010) describes the use of three different CT for a group project in higher education. Groups either used a wiki (i.e. PBworks), a file repository (i.e. Drop.io) or a social networking site (i.e. Facebook Group) to complete the task. Similarly, other studies have also highlighted the adoption of many of

these new breed of CTs for learning and teaching both in organizations and educational institutes (Anderson, 2007; Boyd, 2007; IESD, 2011; Lai & Turban, 2008; Minocha, 2009).

The literature has heralded that these new CTs can promote deeper learning, enhance collaboration skills and facilitate the knowledge discovery of learners (Chen et al., 2005; Mader, 2006; McLoughlin & Lee, 2007; Parker & Chao, 2007; Schroeder, et al., 2010)}. However, many of these claims are based on descriptive studies that have elaborated on the advantages of using CTs for learning. Some research has also involved case studies and learner self-reports.

As the focus of the thesis is on wiki-based CTs, this review will emphasize more on wiki-based research. Moreover, most of the research on learning has been in education rather than in corporations; studies in this review reflect that. Wiki functionality includes open editing (to enable group authoring), versioning (to track the updates to the group project), and a discussion space next to the content (for further discussion and elaboration; Schwartz et al. 2004). These aptly support group collaboration and learning (Cress & Kimmerle, 2008; Larusson & Alterman, 2009; Parker & Chao, 2007; Schwartz, et al., 2004; Wagner, 2004; Wheeler, Yeomans, & Wheeler, 2008). (Please refer to Section 3.61 for more details of the wiki.)

Wikis are a new generation of CTs that are popularly being used in educational landscapes due to the ease of availability through various free hosted solutions and open-sourced solutions (Ebersbach, et al., 2008). Elgort (2007) describes wikis used in education as "academic or learning wikis, incorporating elements of social software, a group project tool and an academic study tool" (p.236).

Wikis have been used in many ways such as the construction of a case library, wiki micropedias (topic-focused encyclopedias), FAQ wikis, crowdsourced textbooks, problem solving wikis, and project spaces (Kane & Fichman, 2009). For instance, one of the forerunners of wiki systems for education is the CoWeb implemented at the Georgia Institute

of Technology (Guzdial, Rick, & Kehoe, 2001). The CoWeb usage can be divided into these three areas: distribution of information, creation of collaborative artifacts, and discussion and review.

Although there are a myriad of uses, wikis are heralded for its ability to allow group authorship in which team members use a shared workspace to discuss and create a co-written document in the context of learning (Parker & Chao, 2007). As previously highlighted, socio-constructivism suggests that people learn best when they share, cooperate, reflect and negotiate with others (Vygotsky, 1978). This theory has been a guiding principle in many educational activities such as team projects.

Nicol et al. (2005) examined a collaborative activity that involved the co-creation of engineering designs using two different types of CT - a digital repository by Orbi and a wiki, TikiWiki. The wiki, in particular, afforded teams the ability to communicate and share resources across and within teams. Both types of CT benefited students who reported satisfied with the tool. The wiki, in addition, allowed easy display and description of files and encouraged the contextualization of the content, although it did not have an organizer and summaries of page contents. Tutors also remarked that the wiki helped to improve the quality of projects compared to earlier batches.

CTs can be used in topic-focused discussion to foster a deeper sense of engagement with the course content through the use of specific subjects of discussion. This is also known as an anchored instruction or discussion (van der Pol, et al., 2006): that is, a collaborative discussion that is “anchored” or contextualized under specific conditions. Through anchored discussion, students are forced to go in depth with the topic. They are able share their own thoughts and consider the multiple perspectives of the group. They are then able to learn from each other and to achieve shared understandings.

For instance, an anchored discussion occurred through the development of a micropedia of concepts and topics on a wiki (Bruns & Humphreys, 2007; Lund & Smødal, 2006). The wiki

micropedia for Bruns and Humphreys (2007) was in a new media technologies course while Lund and Smødal (2006) used it in an English as a foreign language course. In both studies, groups of learners were tasked to co-construct subject entries in the encyclopedia. In the case study, Bruns and Humphreys (2007) found that the although students generally responded positively to the project, the engagement of students, the perceived audience of the work, the communication skills of learners and the assessment of the project were key issues.

Lund and Smødal (2006) documented two courses which used wikis. They found that students who were used to independent writing were uncomfortable with collective writing practices. Still, learners were able to let go of the individual attribution of work and engage in the collective creation of knowledge. These courses enabled students to form a sense of community over time. A concern of the paper is the role of the instructor in the wiki. Wikis do not provide an online space for the instructor as the instructor has the same amount of user rights as the student such as create, edit, move and rename pages and upload files. The instructor's space on the wiki is virtually the same as the student's space. This makes the role of the instructor more ambiguous.

The wiki is also a useful tool for distributed learning. Some studies have recorded wikis used between students of different Universities and countries. For example, Guth (2007) reported a project involving students studying English in an Italian University with students studying Italian at an American University. Students used a wiki to converse and share cultural knowledge with each other. Although students appreciated a shared workspace, there were concerns over ownership of personal contributions.

Nevertheless, most studies have examined wiki-use in blended contexts. Chen et al. (2005) describe the use of blogs and wikis in a project-based course in higher education. In small teams, students used a wiki to build their collaborative designs and the blog to log their reflections. The research found that these CTs enabled students to be aware of what has been learnt and articulate the relationship between learning and the design process. This enriched

the students' learning experience and most students reported higher motivation, self-confidence, and interest in the course. The study suggests that further research should examine gender differences as well as long-term effects.

Witney and Smallbone (2011) explore the use of wikis in two undergraduate business modules. They found that group success was affected by the level of commitment and rapport among group members. Still, the research found that students were positive about using the wiki in the future. Support for technical training and collaborative group practices were suggested.

Past research has suggested that characteristics of the learner and the group could affect learning outcomes (Chang & Lim, 2005; Witney & Smallbone, 2011). In the same vein, Hew and Cheng (2009) review 26 wiki articles and propose several factors that affect wiki usage and outcomes. The work outlined that wiki usability, pedagogical issues, social environment and technical knowledge could affect the use of wikis in education. It also suggests that the experience with CT may play a part in affecting the interests and final learning outcomes of students.

In addition, Hew and Cheng (2009) observe that past research has mainly been descriptive with prescriptive guidelines or a self-reflection without rigorous investigation. Indeed, although there has been more empirical research of wikis used in education, these studies are nonetheless limited in terms of some crucial aspects. For instance, Ramanau and Geng (2009) performed a University-wide survey and found that several demographic characteristics of learners affected wiki use. Male students were more likely to utilize wikis than females. In terms of age, students aged 20 to 25 years were more likely to use wikis than students aged 17 to 19 years of age or students aged 26 years of age and older. However, this research was part of a wider study of IT use in the University and did not provide any theoretical research model or develop further analysis.

Mak and Coniam (2008) examine wiki use for English compositions in a high school. In groups, students were required to use a wiki to collaboratively write a composition. As students were expected to write around 150 words per month, the study found students using the wiki producing a higher number of words. Moreover, the text that was produced was logical and accurate. This trial experiment allowed students to engage in co-writing, which was new and rewarding for students. In addition, the positive response resulted in wikis being adopted throughout the school. Unfortunately, the study did not design a control group in which to compare the effect of wiki use.

Some other empirical studies have examined learner's perceptions of wiki use for learning. Deters (2010) surveyed 40 graduate students who had used wikis in small groups for a group assignment. The participants rated the wiki favorably for learning and identified benefits such as supporting instruction, engaging students, and facilitating communication. The study also identified that technical help on wiki use and training for group processes are needed. Similar, Mirk et al. (2010) investigated learner perceptions of a wiki used in a Pharmacy course. Based on survey results as well as qualitative feedback, the research found that overall learner's satisfaction was neutral. However, most students recommended the wiki to be used in future classes. There was also no significant difference between student's participation in the wiki and academic grades. Student's participation in the wiki also did not affect satisfaction. Nevertheless, the study reported that students perceived that the wiki helped them to clarify course content.

Although there have been more studies providing support of using new breeds of CTs for learning, empirical efforts have not been rigorous. A few studies on wiki effectiveness can be found but are nonetheless limited in terms of some crucial aspects as aforementioned. Most papers provide theoretical explanations or descriptions of the wiki. Therefore, greater empirical efforts to examine learning outcomes from using these new breeds of CT are in want (Forte & Bruckman, 2007).

Moreover, from these studies and frameworks, it can be seen that besides the technology dimension, the human dimension is equally important. Learner characteristics are a key component of the human dimension. Past research has identified several learner characteristics that are salient to CT effectiveness such as wikis. These include age (Ramanau & Geng, 2009), gender (Chen, et al., 2005), CT experience (Hew & Cheung, 2009), perceived instructor support (Lund & Smødal, 2006), and distance/proximity (Guth, 2007). Future research could examine the influence of learner characteristics with these new breeds of CT.

To sum up this chapter, several research trends have come to prominence. First, the I-P-O model is undergoing a transition. Many studies have utilized the I-P-O model to make predictions and examine findings. However, variants of the model have appeared, and some authors have defined a new type of model, the IMOI model (Ilgen, et al., 2005). The I-P-O model is very much a legacy of the functional perspective. Research done in this approach has provided parsimony and inclusiveness. Moreover, radical approaches to group effectiveness research could further divide the already fragmented field (Salas, et al., 2008). Thus, this thesis concurs with the conservationist sentiment of maintaining the I-P-O approach while allowing for variations in the model. Further development of the group effectiveness literature can still occur within the essential frame of the I-P-O model, for instance with intervening and adaptation factors (Fjermestad & Hiltz, 1998; Martins, et al., 2004).

It is in this light that the next trend will be discussed, that is the identification of inputs, processes and outputs. This review has identified several inputs that affect learning outcomes. Of these, two key dimensions seem especially salient: the technology and learner dimension (Piccoli, et al., 2001). Specific characteristics of each dimension should be investigated in future research. For instance, in Section 2.3.2.3, the characteristics of the new breed of CT should come into consideration. As for processes, the review has suggested the importance of identifying salient process variables. As highlighted by many researchers (e.g. Powell, et al., 2004) the communication process in groups is crucial. Many of the process losses in a group,

e.g., information overload, is a result of poor communication (Steiner, 1972). Open communication can possibly enhance the group performance (Baltes, et al., 2002).

Last, a final research trend is the recognition of the social aspect in the group. Previously, much literature concentrated on task behavior. The renewed focus on the social aspect has resulted in research highlighting socio-emotional group processes that include relationship building and trust. Although this is good progress, there has been comparably less research on outputs with a social focus. Most research has examined task-oriented outputs of the group such as performance (Hackman, 1987) or learning achievement (Lou, Abrami, & d'Apollonia, 2001). However, socio-related outcomes such as social climate and cohesion can be equally important (Chidambaram, 1996; Kreijns, et al., 2002; Powell, et al., 2004). An emphasis on the social elements represents views from the psychodynamic perspective. In that respect, focusing on the social aspect in addition to the task aspect allows a possible integration of the functional and psychodynamic perspectives. This could lead to a further development of theory and research originating from the twin pillars of this thesis, i.e., small groups and educational psychology.

This literature review has provided the foundations and the empirical support for the next chapter of the thesis. In the next chapter, we will describe the theoretical framework of CT effectiveness as well as expound on each salient factor of focus.

Chapter 3: Theoretical and Conceptual Development

In this chapter, we develop a theoretical framework and describe the elements highlighted as salient for CT effectiveness. This provides a frame of reference in which to direct the empirical research of the thesis. The research approach will also be described in the last section of this chapter.

3.1 Theoretical Framework

Based on the literature review, a theoretical framework is developed. The overall direction in this thesis is drawn from several theoretical perspectives and frameworks. Earlier in the literature review, two key lenses were identified, the functional and psychodynamic perspectives. These will be used to examine the research questions. Chiefly, the functional perspective provides the overall lens to examine group effectiveness research (Wittenbaum, et al., 2004). In this regard, inputs, processes and outputs will be examined.

The previous review has examined several input characteristics that can affect group processes and outcomes. In line with extant research (Piccoli, et al., 2001), two dimensions of inputs have been delineated. They are the technology dimension which pertains to CT, and the learner dimension which pertains to human-related factors. From the literature, several salient factors have been identified from these two dimensions. These are pertinent in the current context of a new breed of CTs. They consist of the CT characteristics: CT sociability and CT visibility, and the learner characteristics: age, gender, CT experience, perceived instructor support and distance/proximity. These will be elaborated on subsequently.

Communication has been pinpointed as a key process affecting group outcomes (Flammia, et al., 2010; Gladstein, 1984; Powell, et al., 2004). To examine communication, the thesis adopts the communication dichotomy from Bales (1950) which provides one of the most fundamental aspects of communication in groups (McGrath, 1984). Bales (1950) theorized that groups are in a continual state of dividing their time and work between instrumental

(task-related) and expressive (socio-emotional) needs. Thus, task-related and socio-emotional activities are paramount in groups.

In terms of outputs, the thesis proposes to examine learning outcomes from both task and social orientations. In line with the psychodynamic perspective, which espouses relational change, socio-related outcomes are examined. The current study intends to investigate learning outcomes in terms of learning performance and socio-related outcomes. Specifically, the learning performance consists of academic achievement, self-reported learning, process satisfaction and solution satisfaction (Bloom, 1956). Socio-related outcomes are in terms of perceptions of a positive social environment and sense of community (Chou & Min, 2009; Kreijns, et al., 2002).

The functional perspective postulates the examination of task-related activity and the I-P-O model. On the other hand, the psychodynamic perspective encourages the investigation of socio-emotional activity and the socio-related performance. This conceptualization intertwines the two group perspectives and is a form of integrative theory (Berdahl & Henry, 2005).

The theoretical framework guiding this thesis is illustrated in Figure 3.1. The technology and learner dimension are part of the social context in any learning group (Brandon & Hollingshead, 1999). These inputs to the group will likely affect learning outcomes directly. In addition, the social context also could affect the communication process consisting of task-related and socio-emotional activities. The two communication activities will subsequently affect the learning outcomes.

As implied by earlier research, interacting relationships might also affect group outcomes. Research has suggested that human behavior is a result of a continuous process of multidirectional interaction or feedback between the individual and the situation encountered (Sharda, et al., 2004; Terborg, 1981). Specifically, learner characteristics have been proposed to moderate the relationship between CT characteristics and learning outcomes (Chang &

Lim, 2005; Fjermestad, 1998; Sharda, et al., 2004). In other words, it is inadequate to conceive of a single relationship that affects learning outcomes, rather, a multidirectional interaction exists. Therefore, the thesis conceptualizes interactions among CT characteristics and learner characteristics in affecting learning outcomes. Another interaction effect is also proposed between inputs of the social context and the communication process which can influence learning outcomes.

Each component of the framework will be elaborated on in the upcoming sections. A table describing the several key constructs of the study and relevant acronyms is summarized in Table 3.1.

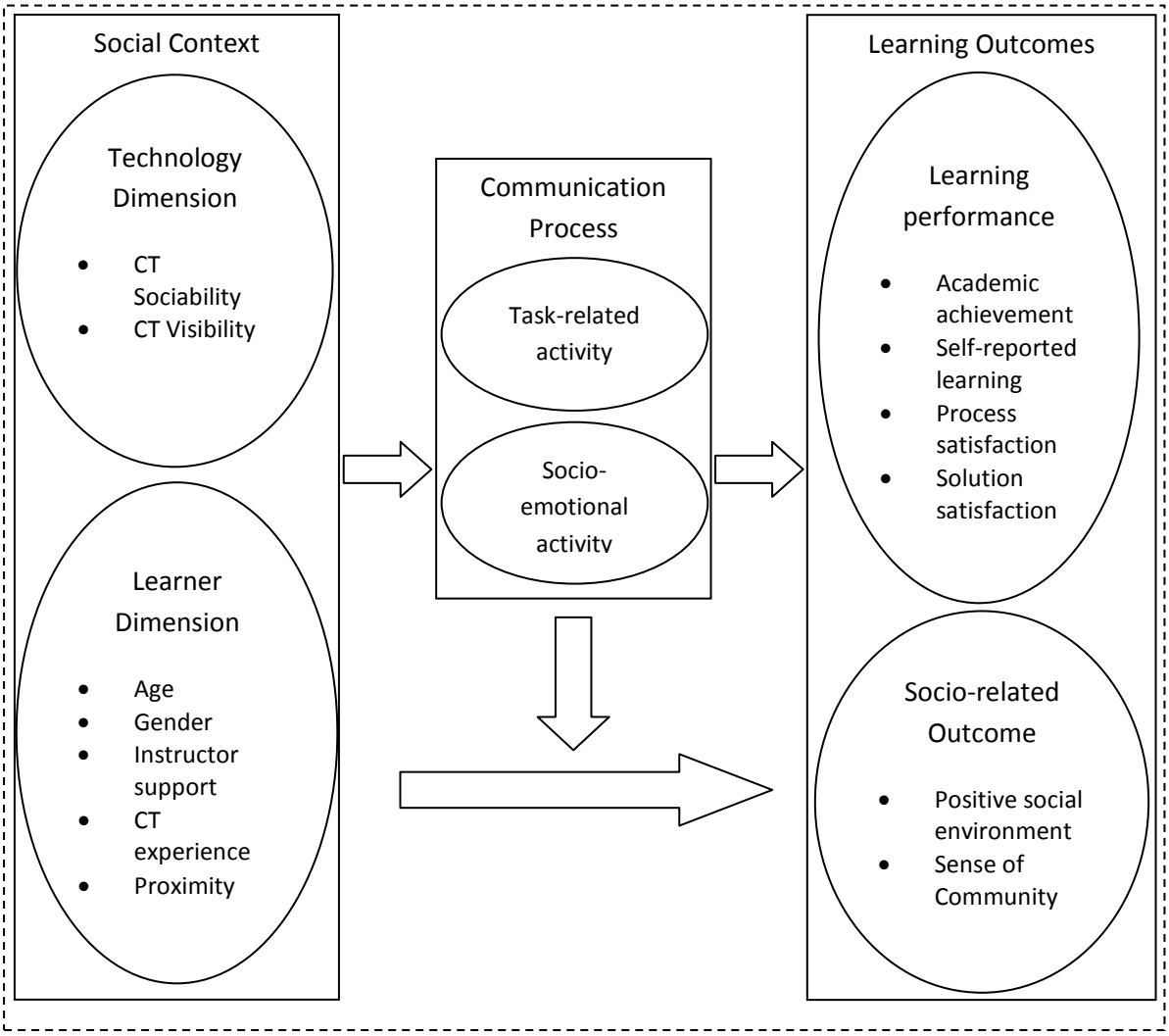


Figure 3.1 Theoretical Framework of CT Effectiveness

Table 3.1 Summary of Several Key Constructs

Construct	Acronym	Definition	Reference
Academic achievement	ACA	Cognitive gain of learners	(Bloom, 1956)
Process satisfaction	PSA	Degree to which the learner feels a positive association with the learning process	(Ocker & Yaverbaum, 2001)
Positive social environment	PSE	Overall social climate of the team in terms of good work relationships, trust, respect and belonging	(Kreijns et al., 2007)
Sense of community	SCO	The feeling of connectedness among the learners	(Rovai, 2002)
Socio-emotional activities	SEA	Behavior that is focused on feelings and the self. E.g. expressing friendliness, encouragement, providing personal information	(Bales, 1950; McGrath, 1991)
Sociability	SOC	Extent to which CT facilitates the emergence of a sound social space in which healthy social relationships among team members are formed, as seen in group norms, roles, and beliefs	(Kreijns et al., 2002)
Self-reported learning	SRL	Perceived cognitive knowledge and/or skills developed by learners	(Bloom, 1956; Alavi, 1994)
Solution satisfaction	SSA	Degree to which the learner feels a positive association with the learning result	(Green & Taber, 1980; Ocker & Yaverbaum, 2001).
Task-related activities	TRA	Behavior that is focused on work. E.g. asking for information, providing information on the task	(Bales, 1950; McGrath, 1991)
Visibility	VIS	Modes of access to a collaborative workspace	(Bruns & Humphreys, 2007; Guth, 2007)

3.2 CT Characteristics

The design of CT is crucial to learning outcomes. In this thesis, the technology dimension denotes the design of CT. As mentioned in Section 2.3.2, a decompositional approach is adopted to further understand CT design. The literature review identified five salient characteristics of CT: information structure, communication support, visibility, connectivity and sociability. This thesis will highlight two CT characteristics – sociability and visibility, which are especially pertinent in the current context of wiki-based CTs. Although the other three identified characteristics are important in their own ways, theoretical and practical limitations prevent further investigation. Sociability and visibility have not been examined rigorously in the extant literature unlike work on other characteristics such as communication support (e.g. Wagner & Schroeder, 2010). These two characteristics also create issues in learning groups that have wide theoretical implications. Practically, examining all these

characteristics requires substantial resources to develop and test the CT. Nevertheless, these three other characteristics are salient to CT effectiveness and should be investigated in future research. The following sections explain further the relevance and importance of sociability and visibility.

3.2.1 Sociability

Developments in the computing world have seen a mounting trend of sophistication with many CTs designed to encompass many modules of interactivity. Instead of software for use in group meeting rooms, CT is increasingly web-based, making use of virtual servers and cloud computing. With the influx of Web 2.0 concepts such as increased participation and social networks, CTs have increasingly accommodated more sociable characteristics, which are defined in the paper as sociability. Basically, there is not just one asynchronously shared workspace; rather there are multiple avenues for individuals to interact. For instance, Google Docs, an online authoring workspace, has an additional chat feature while WetPaint, a hosted wiki, allows users to embed polls and chats. Some proponents have also termed this new generation of software, "social software" (Shirky, 2003) to denote software with features that connect individuals rather than just perform a certain function only.

Sociability refers to *the extent to which CT facilitates the emergence of a sound social space in which healthy social relationships among team members are formed*, as seen in group norms, roles, and beliefs (Kreijns, et al., 2002). It is based on the theories of social affordance (Gibson, 1986) and teleproximity (Festinger, Schachter, & Back, 1950). Social affordances are properties of the technology that play the role of socio-contextual enablers for the users' social interactions. They are the social aspects of technological affordances and encourage a reciprocal relationship between the user's social intention and an episode of interactivity via technology. A perception-action coupling also exists as the technology enables a user to perceive the presence of another user and initiate an interaction with the user. The teleproximity concept refers to the perception of nearness and immediacy of the technology.

The feeling of proximity in virtual settings encourages both informal and planned encounters, which enhances social interaction. Just as the proximity of water coolers enable face-to-face interaction, the teleproximity that CTs engender also encourages computer-mediated communication among team members.

Preece (2000) defined sociability as the design of online community systems which enable members to share a common purpose and enjoy the interaction with each other. Although similar to the sociability construct described by Preece (2000), the thesis defines sociability within the context of members in a team rather than an online community. Sociability might also seem to resemble usability; however sociability describes the human-human interactions among members facilitated through technology while usability refers to the human-computer interaction i.e. how users interact with the technology interface.

Sociability might also seem to resemble social presence and media richness. Unlike social presence, which is the degree of salience of the user in the mediated interaction and the consequent salience of the interpersonal relationships (Short, Williams, & Christie, 1976), sociability is a feature of technology and not a perception of users. Moreover, CT sociability helps to increase social presence (Kreijns, Kirschner, Jochems, & van Buuren, 2007). On the other hand, there are some similarities between sociability and media richness. Media richness theory as described in Section 2.3.2.1, postulates that different media permit the transmission of different cues (Daft & Lengel, 1986). Media richness and sociability are similar in that both allow the transmission of multiple cue types. High CT sociability can be considered rich media while low CT sociability is leaner. Conversely, there are several differences between media richness and sociability. A chief dissimilarity is that media richness considers all media including face-to-face and non-IT forms while sociability is only concerned with computer-mediated media. Second, media richness theorizes that there must be a fit between the richness of the media and the complexity of the transmitted message. Sociability does not predict any such relationship. In addition, the effect of sociability is informed by media richness theory.

A CT high in sociability would be represented by features which elicit more interaction between team members. High CT sociability would support scheduled meetings and opportunistic interactions (Poltrock & Engelbeck, 1997) with features such as status awareness indicators, shared workspaces, user profiles, calendars and group chat rooms (Kreijns, et al., 2002). For instance, having a purposefully designed online chat room for the project task with the CT would encourage members of the group to engage in formal discussions and also allow opportunistic interactions when members happen to see each other using the CT.

Boyd (2007) argues that the sociability feature of CT strongly augments learner-centered instruction due to support for informal conversations, social feedback, social networks and relationship among individuals. Clark et al. (2007) add that dialogic argumentation will be enhanced with CT designed with collaborative communication interfaces and the co-creation and sharing of intellectual artifacts. Dialogic argumentation is the process of learners exchanging opinions and challenging the validity of those ideas in order to gain a better understanding of challenging concepts and to improve reasoning skills (Clark, et al., 2007). In sum, CT sociability could embed new ways for collaborating online and affect learning outcomes (Cress & Kimmerle, 2008; Laurillard, 2009).

3.2.2 Visibility

Besides facilitating team-based collaboration, CT provides the ability for group workspaces to be shared with other people. Specifically, group workspaces can be viewed privately, i.e. viewed only by team members, or publicly, i.e. viewed by any person on the World Wide Web. This paper terms the *modes of access* to a collaborative workspace as “visibility”. In the public mode, team members’ edits and contributions to the CT are visible to members of the general public. In contrast, the private mode keeps the document's visibility to team members only.

This characteristic of visibility was previously not easily implementable with earlier non-

networked CTs. Now that it is a key characteristic of CT, usually by the configuration of an access mode, concern over visibility has been raised in several papers (Bruns & Humphreys, 2007; Wheeler, et al., 2008). Most anxiety is with regard to the public mode of visibility where several advantages and disadvantages could arise. For instance, learners may feel daunted and unwilling to contribute if their work is exposed to other peers and members of the public. On the other hand, public visibility may cause learners to be more aware of the audience and put in more effort in their assignments.

Ramanau and Geng (2009) describe the instructional design for group work in a beginner Japanese module in higher education. Using a Confluence wiki, the course set a public area for the whole class which had general instructions and a private group workspace for each of the 13 groups for their group project. The private group area could be made public when the group members were ready to share the project with other groups. In essence, this design had furnished the group with a "privacy period" during which students had the freedom to be left alone to collaborate in private. At the end of this period, the public would get to see the group's work. What if students were deprived of the privacy period and had to collaborate publicly? The transparency of the collaboration process could affect team member's collaboration and outcomes. Hawkey and Inkpen (2006) suggest that the comfort level of the user in displaying personal information in the presence of an onlooker is affected by the sensitivity of the information being displayed and the identity of the viewer.

Some understanding of the effect of visibility can be drawn from earlier education research on audience analysis and writing publication on the Internet. Researchers found that students produced better writing when they wrote to communicate with an audience compared to writing to demonstrate their skill to the teacher (Cohen & Riel, 1989). Students would take on the perspective of the other, devote more attention to the content and organization of their compositions in writing for the directed audience. The research suggests that the public level of visibility of the Internet by providing an intrinsically meaningful context of learning and a distant audience, would increase student motivation and lead to better learning outcomes.

Karsten (2003) from the interdependence perspective conceived that reciprocity among the group will be affected by system integration and visibility. Some evidence for visibility's impact on learning outcomes has been reported (Guth, 2007; Minocha, 2009). In a qualitative study, Guth (2007) compared the influence of private and public visibility in a course wiki. The research found that the public wiki enabled wider collaboration, empowered students and increased the quality of student's work, yet it was more challenging for the educator to handle, and it caused more student frustration and discomfort. In both cases, students contributed actively and were able to learn from the content. Research has also found that high visibility could motivate students to put more effort into their projects resulting in higher cognitive gain (Minocha, 2009).

3.3 Learner Characteristics

The learner dimension refers to characteristics that pertain to the learner in the course or project. A review of five salient characteristics is put forward.

3.3.1 Age

The age of learners could affect outcomes. There are two perspectives of how age affects outcomes. The first is with regard to the current generation who are growing up with technology compared to the older generation who adopt technology at their older age such as those born after and before 1985. Some research suggests that younger individuals tend to spend more time using the Internet, engage in more intensive Internet activities and easily employ technologies as compared to older individuals (Hills & Argyle, 2003; Karuppan, 2001). Prensky (2001) even coins the term "digital natives" to describe younger individuals who seem to naturally adopt digital technology in contrast to "digital immigrants", the older generation who require a higher learning curve to utilize technology. This implies that due to the ease of usage and familiarity with CTs, younger learners could perform better than older learners.

Another perspective on age draws from developmental theories. Due to developmental

transitions, adolescents and younger adults seek new experiences while older adults and those in middle adulthood seek stability (Harter, 1999). Older students are typically more mature, more disciplined, and have wider life experiences than younger students which may allow them to successfully adapt to challenges in projects using online collaboration application. Moreover, older students tend to value their time more than younger students and may be more satisfied with the convenience that CTs afford. This implies that older students might have higher learning outcomes than younger learners as found by several studies (Dille & Mezack, 1991; Swan, et al., 2000). Although some studies found significant differences between age and outcomes (Swan et al., 2000), others report no significant differences (Hong, 2002; Karuppan, 2001). There is no conclusive evidence for the effect of age on learning outcomes and further research is required.

3.3.2 Gender

Gender difference among learners has affected the adoption, use and outcomes of technology. Males tend to adopt technology more readily and have less computer anxiety than females (Durndell & Thomson, 1997; Ong & Lai, 2006). More so with new technologies, males are likely to have more experience with them. Ramanau and Geng (2009) found that males were more likely to have experience with wiki technology compared to female students.

Even so, in online collaboration, the nature of communication styles differs between males and females. In discussion posts, males tend to come across authoritative and argumentative compared to females who seem to be more encouraging and nurturing (Guiller & Durndell, 2007; Lind, 1999; Thomson, 2006). In an online forum, females were found to request for more information than males, whereas males provided more explanations and had a higher number of messages (Robertson, Hewitt, & Scardamalia). Moreover, Richardson and Swan (2003) found that females perceived higher social presence than males in an online course. Especially in online learning, females prefer to work collaboratively compared to males (Jeffrey, 2009).

One explanation for gender differences is the task and relationship orientation (Hahn & Litwin, 1995). This view posits that males are task-oriented and value self-sufficiency as they see relationships in terms of status and dominance. In contrast, females are relationship-oriented and nurturing and are more willing to empathize with others. This suggests that females are more likely to prefer collaboration than males.

Some research has found that gender does affect learning outcomes in technology-mediated environments. In a virtual team project, males were less satisfied and perceived less cohesion than females (Lind, 1999). On the other hand, females believed that the group conflict was readily resolved compared to males. Similarly, Swan et al. (2000) found that females had higher student satisfaction and self-reported learning than men. The research attributed this to the equalitarian nature of online discussion where females felt more freedom to participate.

Despite the findings on gender differences, some authors downplay the saliency of gender. Hong (2002) suggests that gender could be a proxy for expectation. Females being more skeptical about using new technology could have been more pleasantly pleased with the result. Other research has found no significant differences among gender in technology-mediated learning. For instance, Phadtare et al. (2009) found no significant differences among genders in terms of academic achievement and satisfaction when students used CT.

3.3.3 Perceived Instructor Support

The role of the instructor in virtual environments is increasingly being studied (De Laat, Lally, Lipponen, & Simons, 2007; Lund & Smødal, 2006). Most schools of thought in educational research have highlighted the importance of the instructor. Instructor intervention is beneficial in order to scaffold the learning ability of students so that learner can solve problems or accomplish tasks that would otherwise be out of reach. Instructors could also act as technical support especially with regard to students who are unfamiliar with using CT. Moreover, the interaction between students and instructor could create a sense of presence of the instructor. The instructor's presence has been found to be positively associated with

student's perceived learning (Richardson & Swan, 2003). Conversely, a lack of instructor presence could cause feelings of isolation, alienation and dissatisfaction among students (Gunawardena, 1995; Johnson, 2005; McInnerney & Roberts, 2004).

On the other hand, another school of thought is that students should use CT without the interference of the instructor. The teacher's presence could stifle the creativity and learning of students involved in collaborative group work. In essence this is what Cohen (1994) postulated in her definition of cooperative learning where students work together in a small group "without direct and immediate supervision of the teacher" (p.3). Nevertheless, in technology-mediated environments, there is still supervision by the teacher, albeit in a more indirect process. This could take the form of instructional design and structure developed by educators and educational technologist (Kanuka, Rourke, & Laflamme, 2007) without any direct intervention by the instructor. In that sense, although the instructor is not available, yet some sort of guidance is still given. Students have to take on the challenge of self-managing their own team in order to complete the project.

Garrison, Anderson, & Archer (2000) developed a community of inquiry framework to guide the development of research and practice in online learning which is based on the three elements of teaching, social and cognitive presence. They contend that these interactions have to be directed and refined towards a specific goal. Teaching presence is therefore required "to design and integrate the cognitive and social elements of a community of inquiry for educational purposes" (p.92). A large body of evidence supports the relationship between teaching presence and learning outcomes (De Laat, et al., 2007; Kanuka, et al., 2007). Therefore instructor support is an important factor to be considered.

3.3.4 CT Experience

Previous CT experience could affect subsequent interaction processes and outcomes. Past literature has suggested that previous computer experience is a differentiating factor with students who use IT tools to learn (Lou, et al., 2001; Shih, Muñoz, & Sánchez, 2006; Yan,

2006). Individuals with more computer experience have more positive attitudes towards computer use (Nelson, 1990), higher comfort levels (Lou, et al., 2001), and self-efficacy (Padilla-Meléndez, Garrido-Moreno, & Aguila-Obra, 2008).

Fishman (1999) suggests that higher experience with the tool is inversely related to the amount of effort needed to utilize the tool. The study found that student experience with computers enhanced the frequency of CT use. Koohang (2004) showed that students with more prior experience with the Internet had higher acceptance of IT; they had more positive perceptions towards using the digital library in their weekly web-based distance learning assignments. Students who had more computer experience were more satisfied with their web-based course (Hong, 2002) while students who lacked computer experience experienced more stress and anxiety with IT (Lou et al., 2001).

However, other research has shown that previous computer experience does not affect student attitudes or learning outcomes (Padilla-Meléndez, et al., 2008; Shih, et al., 2006). For instance, Shih (2006) found that previous computer experience did not influence the performance and satisfaction of using a virtual classroom. Rather computer experience affected the methods and speeds to which the learner went through the course. More experienced learners spent less time and less page visits to the virtual classroom.

These studies suggest mixed findings on the effect of computer experience on learning outcomes. Similarly, the effect of CT experience on learning outcomes has yet to be fully explored. More research is needed.

3.3.5 Proximity

Another recent trend is the adoption of global virtual teams in the workforce brought about by the connectedness of IT. This has led to a line of research examining virtual teams and the effects of proximity and distribution. Moreover, blended learning, in which collocated students participate in a mixture of computer-mediated and face-to-face instruction, has

grown in popularity(CDW-G, 2010); the effectiveness of using CT in collocated contexts has been called into question (Diaz & Brown, 2010; U.S. Department of Education, 2010). However, past literature has hardly examined the use of CT in these environments.

Proximity is the *nearness of team members* and teams can be differentiated into collocated i.e. all members located in the same place, and distributed i.e. members are dispersed across different areas and even countries. Collocated teams that use CT rarely meet physically although they could have occasional face-to-face sessions. However, the face-to-face mode of collaboration is not predominant. On the other hand distributed teams that employ the use of CT do not meet face-to-face. Teams that are collocated are spatially, temporally and culturally close while distributed teams are of the reverse (Chudoba, et al., 2005; O'Leary & Cummings, 2007; Ocker, Huang, Benbunan-Fich, & Hiltz, 2009). Proximity can affect the learning outcomes of members due to spatial, temporal, and cultural separation.

Physical distance decreases feelings of closeness and affinity, and is also inversely related to conflict (Mortensen & Hinds, 2001). Despite the use of CT, research has shown that distributed teams have more conflict and misunderstandings than collocated teams (Cramton, Orvis, & Wilson, 2007). Cramton (2002) suggests that fundamental attribution errors (Jones & Nisbett, 1971) occur in distributed teams where members tend to associate dispositional attributions on distant teammates while collocated teams had more situational attributions.

Temporal proximity also affects the real-time problem solving of teams (O'Leary & Cummings, 2007). When teams are dispersed across time zones, it is more difficult to coordinate schedules and work activities; feedback cycles are also delayed (Chudoba, et al., 2005). Cummings et al. (2009) found that distributed teams with non-overlapping work hours had more coordination delay than those with overlapping work hours even with the use of asynchronous tools such as email.

Culture is seen in terms of national culture (Hofstede, 1980). A common background and similar language patterns fosters communication and reduces the likelihood of

misunderstandings in teams (Zenger & Lawrence, 1989). Cultural proximity also facilitates the development of shared norms and socialization (Connaughton & Shuffler, 2007). On the other hand, cultural diversity leads to both task and affective conflict (Mortensen & Hinds, 2001; Pelled, 1996). Cultural differences especially in terms of race reduce commitment and cohesion (Riordan & Shore, 1997). These differences can be explained by similarity-attraction theory (Bryne, 1971) in which people who think they are alike feel more comfortable in each other's company, view each other as more predictable than other people, and have more confidence in each other (Pelled & Xin, 2000).

In sum, spatial, temporal and cultural distance affects the collaboration experience and eventual outcomes. In the education literature, there has been nascent research on the effects of proximity. However, the rise of blended learning in which collocated students learn from a mixture of online and face-to-face approaches prompts the need for more study on the impact of proximity (Diaz & Brown, 2010; U.S. Department of Education, 2010).

3.4 Communication Process

There is a strong chain of evidence that group communication affects outcomes (Te'eni, 2001). For instance, the communicative action theory (Habermas, 1976) postulates that individuals are able to change their environment via communication. Group communication is seen as a series of communication acts, with different types of social actions, validity claims, and resolutions/breakdowns (Habermas, 1976). Similarly, the group interaction process lens (McGrath, 1984) posits of groups in action through communication patterns. The intention of the thesis is to analyze the perceived communication of members in the group in terms of task-related and socio-emotional activities which has been suggested as the most fundamental of communication activities (Bales, 1950).

The importance of both task-related activity and socio-emotional activity in group work can be seen from several theoretical frameworks. Pioneer small group research by Bales (1950) showed that groups are in a continual state of dividing its time and work between instrumental

(task-related) and expressive (socio-emotional) needs. The research theorized an equilibrium model in which groups seek to maintain a balance of instrumental and expressive acts through three progressive stages – orientation, evaluation, and control. Successful group outcomes then depend on how groups are able to solve the task and maintain member satisfaction.

The Time, Interaction and Performance Theory (McGrath, 1991) also demonstrates the saliency of task and socio-emotional activities. The theory states that in a group, three performing activities occur – production (problem solving, task performance), member-support (member inclusion, participation), and team well-being (member norms and roles). Relationship development, i.e. socio-emotional activity, in groups involves the member-support and group well-being components. Similar to Bales, McGrath conceives that effective teams are those that engage simultaneously and continuously in activities relating to production, member-support and team well-being across the span of the team's work life.

In the education literature, several frameworks have depicting the task-social dichotomy (Baker, Andriessen, Lund, van Amelsvoort, & Quignard, 2007; de Vries, Lund, & Baker, 2002; Schellens & Valcke, 2006). De Vries et al. (2002) describe that in online learning environments dialogues can be classified into a management category which entails interaction, task and off-task communication. The "interaction" is similar to team well-being in McGrath's theory.

Another framework by Baker et al. (2007) called, Rainbow, is based on 7 principal analytic categories of learner communication. The framework first distinguishes between activity that is part of the learning activity or that which is outside. Next, it dichotomizes these inside-activities to be either task-focused or non-task-focused. The framework further categorizes non-task-focused activity i.e., socio-emotional communication, as either social relations or interaction management. Task-focused activity on the other hand is further delineated as task management, opinions, argumentation, explore and deepen. Although the Rainbow framework does not specifically predict that task and socio-emotional communication are

important for learning outcomes, by its very classification of principal categories, it shows that both the task and socio-emotional aspects are important for learning.

Based on quantitative and qualitative research on collaborating student teams on a problem task, Barron (2003) conceives that the process of collaboration, which is seen through communication behavior, is a dual-problem space. This dual-problem space is one in which "participants must simultaneously attend to and develop a content space and a relational space" (p.310). A dual-problem space consists of a content space, referring to communication on the task, and a relational space, referring to interpersonal relations among learners. This is similar to the task-related versus socio-emotional dichotomy that the thesis has been highlighting. Moreover, Barron found that successful groups had sustained discussions, and affirmed and accepted ideas from others. The study demonstrates that groups who learnt more and had higher academic performance were those that were able to negotiate and pay attention to both the content and relational space.

In addition, Geer (2006) highlights the importance of social interactions in a "framework of technology-mediated interaction for education" (p. 133) where social interaction forms the base of a pyramid for different types of interactive pedagogies. The research stresses that social interaction is a crucial foundation for interaction over CMC especially for group collaboration.

In this thesis a key assumption is that socio-emotional activity is predominantly positive in nature rather than negative. This is because positive reinforcements need to exceed negatives ones in order for a group to be viable and complete its purpose (Bales, 1953). If there is only negative communication, the group will break down and not complete its task.

The intention of this thesis is to analyze both the task-related and socio-emotional activities of members in the learning group as we are concerned with "overt interpersonal behavior between members of the group" (Jacques & Salmon, 2007, p. 16). These explicit acts or impressions are crucial for the success of collaborative learning.

3.5 Learning Outcomes

The outcomes of interactions in online collaborative learning can be conceptualized to affect the learning performance and socio-related outcomes of students (Chou & Min, 2009; Kreijns, et al., 2002). These are collectively known as learning outcomes.

3.5.1 Learning Performance

Learning performance evaluates the cognitive and affective learning outcomes of the learner. An influential approach to assess learning performance was conceived by Bloom (1956) and has been widely applied to learning assessment. Bloom's (1956) "Taxonomy of Educational Objectives" classified learning outcomes into two main domains – cognitive and affective.

The cognitive domain of learning tends to be stressed in education as academic skills. These fall into six categories. The first category is basic knowledge such as memorizing facts, figures, and basic processes. The second level is secondary comprehension which is the understanding and illustrating of the facts while the third is application that generalizes the facts to other contexts and situations. The fourth category is analysis which is the understanding of why facts are the way they are. The fifth level is synthesis that aims to make connections between different elements. Finally, evaluation is the sixth component that requires students to use their own knowledge to critically ascertain the quality of information.

The first two components are sometimes termed surface learning or lower-order skills while the last four categories are considered deep learning or require higher-order thinking. The higher-order skills requires both knowledge and comprehension, thus all categories of cognitive learning are emphasized.

Cognitive learning can be measured objectively using course grades, this is termed academic achievement. Academic achievement refers to the *cognitive gain of learners*. Academic achievement is based on the instructor's assessment of the student's performance based on instructional objectives. On the other hand, subjective measures of learning have been shown

to be a valid measure, being consistent over time and across different populations (Pace, 1990). Self-reported learning is the *perceived cognitive knowledge and/or skills developed by learners*. For instance, Alavi (1994) developed a self-reported learning scale based on Bloom's cognitive taxonomy which was found to have high internal validity and reliability.

Another aspect of learning performance concerns affect. The affective domain refers to student's perceptions of satisfaction, attitudes, respect, and appreciation for the learning experience (Sharda et al., 2004). An important measure is satisfaction that has been widely used as a key measure of success in fields such as education, IS, human-computer interaction and marketing research (DeLone & McLean, 2003; Dewiyanti, Brand-Gruwel, Jochems, & Broers, 2007; McKeen, Guimaraes, & Wetherbe, 1994; Wu, Tennyson, & Hsia, 2010). Satisfaction can be evaluated on the process and the solution (Green & Taber, 1980; Ocker & Yaverbaum, 2001), the course (Alavi, 1994), the instructors (Richardson & Swan, 2003) and the delivery medium or system (DeLone & McLean, 2003; Shih, et al., 2006).

Due to the project work nature of the research study, satisfaction is evaluated on the process and the solution of problem-solving in the collaborative activity. Process satisfaction is *the degree to which the learner feels a positive association with the learning process* (Ocker & Yaverbaum, 2001). This measure is envisaged to assess the affective dimension of the group-learner, group-instructor, and group-interface interactions. Solution satisfaction is *the degree to which the learner feels a positive association with the learning result* (Green & Taber, 1980; Ocker & Yaverbaum, 2001). The emphasis here is on the project or deliverable that the group has produced.

In sum, the learning performance of online collaborative learning includes academic achievement, self-reported learning, process satisfaction and solution satisfaction.

3.5.2 Socio-related Outcomes

The importance of the social environment in online collaborative learning has recently been acknowledged (Gunawardena, 1995; Kreijns, et al., 2002; Liu, 2002). An early pacesetter, Gunawardena (1995) observed that coordinating failures of online computer conferencing "tend to occur at the social level far more than at the technical level" (p.148). Still, socio-related outcomes have not been rigorously emphasized in the past.

What exactly is socio-related outcome? Socio-related outcomes are not associated with the social performance of organizations in corporate social responsibility. Rather, socio-related outcomes deal with feeling, being and relationships. It is a measure of the student's ability to interact with other people and to function in groups. More specifically, socio-related outcomes emphasize the social environment as a result of interactions in the online collaborative system.

Rourke (2000) advocates that online collaboration requires students to trust and feel close to each other, and to sense camaraderie and comradeship before they will engage in valuable collaborative behavior. Martin-Dunlop and Fraser (2008) examined student cohesiveness, instructor support, investigation, cooperation, open-endedness, and material environment as part of the learning environment. They found that these social dimensions improved when an innovative science classroom was implemented. Similarly, Alavi (1995) examined the emotional learning climate of collaborating MBA students in terms of team members' attraction to and feelings toward their teams.

This thesis examines socio-related outcomes predominantly in terms of positive social environment and sense of community. Positive social environment is the *overall social climate of the team in terms of work relationships, trust, respect and belonging* (Kreijns, et al., 2007). A positive social environment emphasizes the learning group's rapport and interdependence (Kreijns, et al., 2007). Sense of community refers to the *feeling of connectedness among the learners* (Rovai, 2002).

3.6 Research Approach

With the theoretical framework as the basis, three empirical studies are designed. The first empirical study is a *foundational* examination of the framework. It examines the social context of technology and learner dimensions and its effect on learning outcomes. The second study focuses on the communication *process* in learning groups. It investigates task-related activity and socio-emotional activity and its impact on learning outcomes. The third study integrates the previous two studies by examining the inputs and the processes and their relation with learning outcomes. In addition, the third study highlights several *interactions* including the relationship between inputs and processes. Each area of the three studies relevant to the overall framework is highlighted respectively in Figure 3.2, Figure 3.3, and Figure 3.4.

All three studies utilize the wiki as the CT of focus, which is a new breed of CT that has gained popularity for use in team projects in educational and business institutes. The next section provides details on the wiki while the last section offers a summary of the three empirical studies.

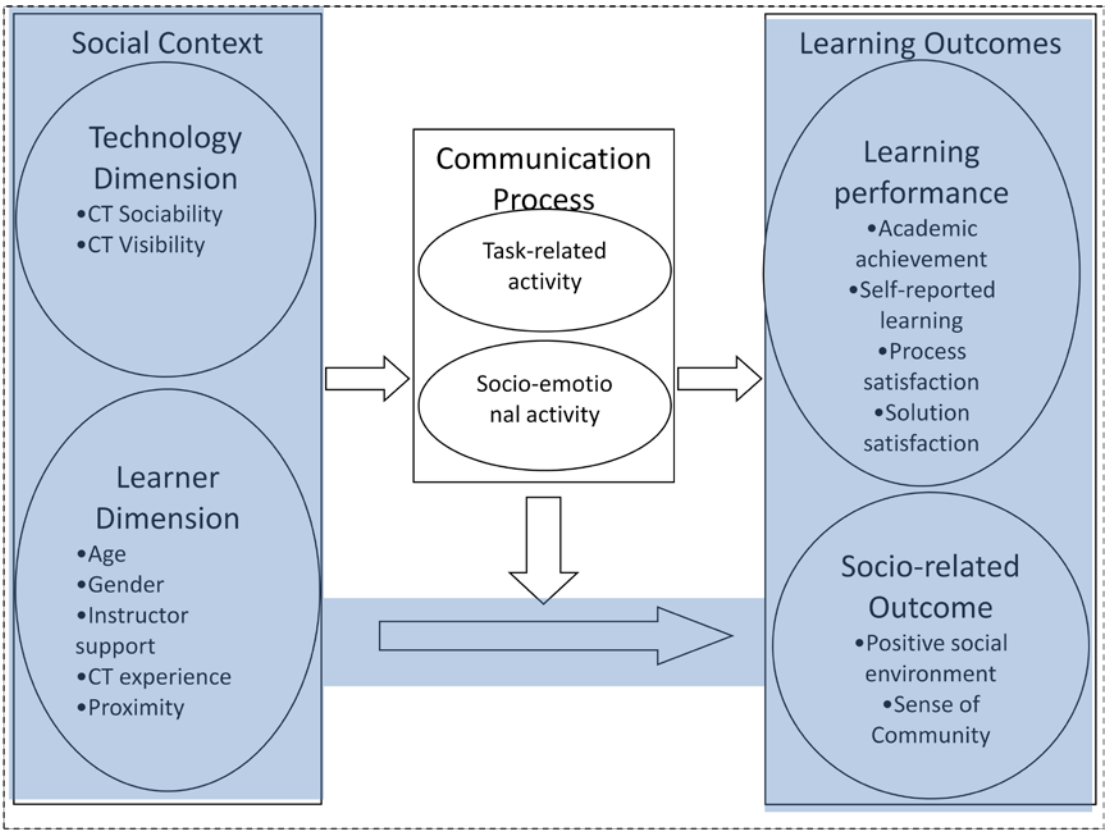


Figure 3.2 Theoretical Framework in Relation to Study I

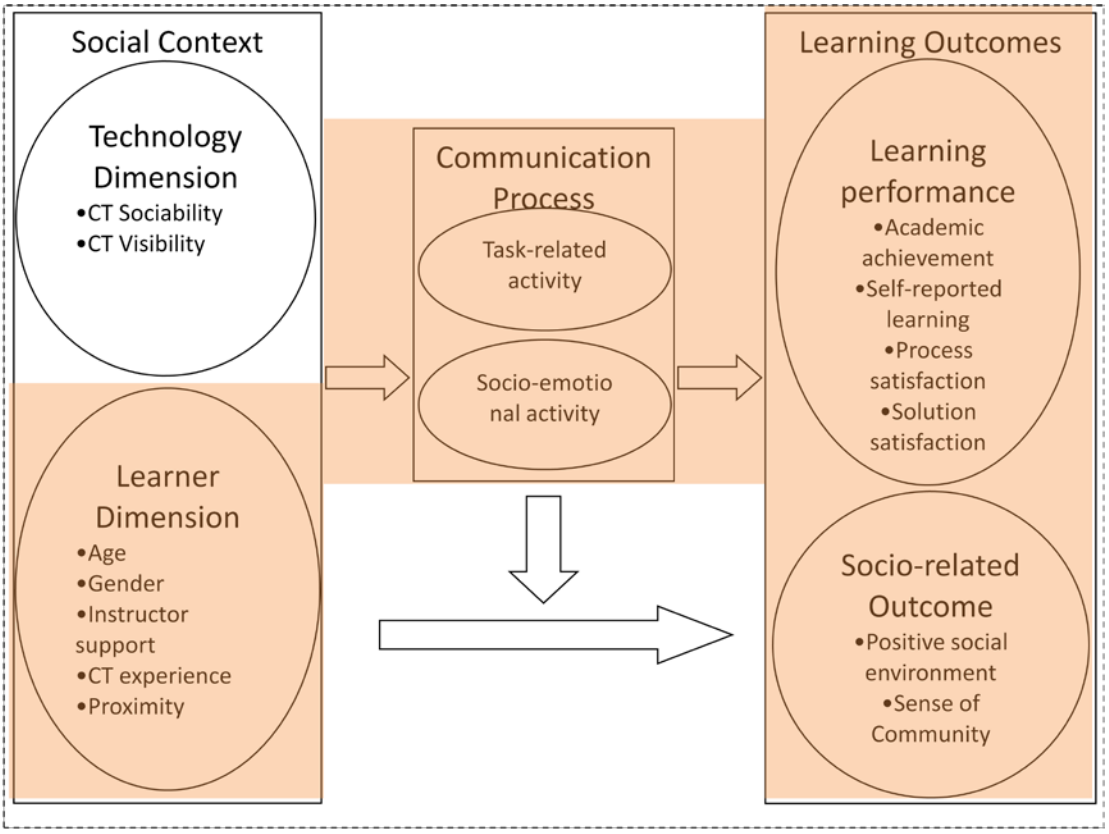


Figure 3.3 Theoretical Framework in Relation to Study II

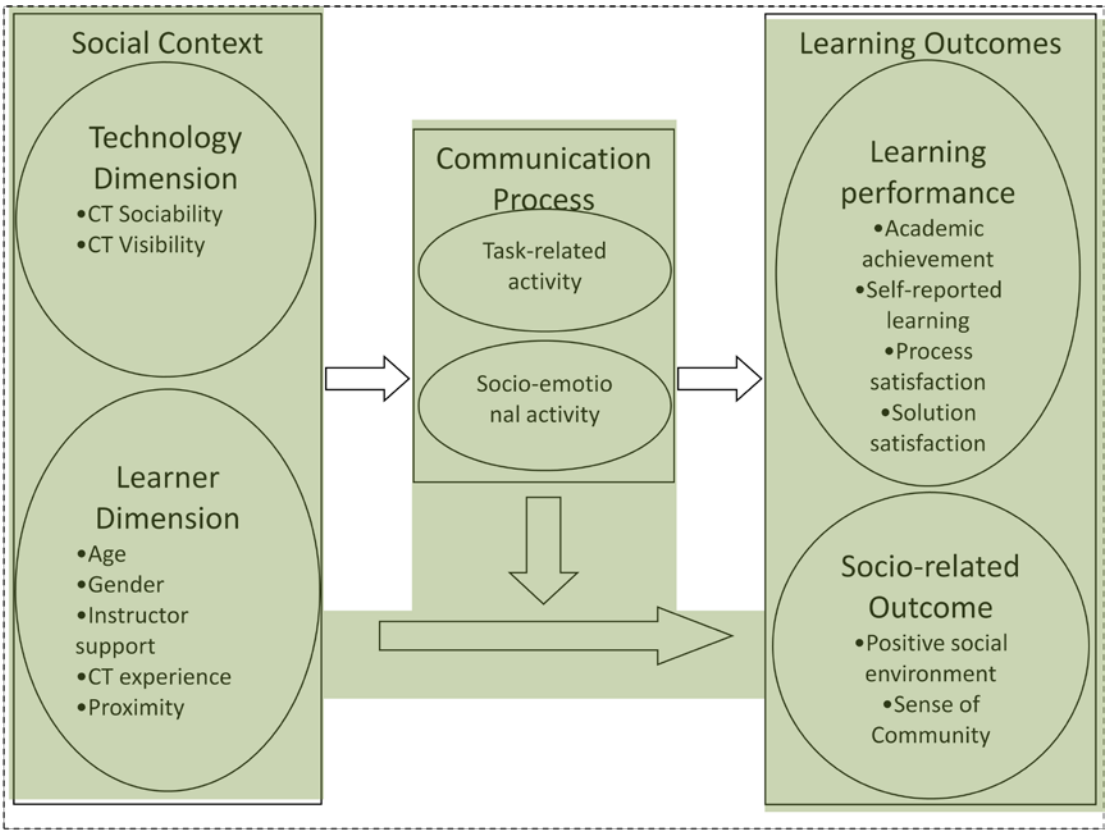


Figure 3.4 Theoretical Framework in Relation to Study III

3.6.1 The Wiki as CT of Focus

Wikis are basically webpages in which anyone can edit. The term “wiki” or “wiki-wiki” is a Hawaiian word for “quick” or “swift”. Ward Cunningham developed and coined the first wiki, the WikiWikiWeb in 1995 (Leuf & Cunningham, 2001). The speed in which pages can be created is one of the fundamental concepts behind wikis. Wiki pages go through three simple steps – write (edit), save, and display. Wikis are a web-based technology and are primarily developed open-source. The software is called a wiki engine; users can choose to install and run the wiki engine on their own or use hosted wikis. Wikis are accessed by any web browser thus no additional software is needed. They are available at anytime and at anyplace.

Wikis have been used by individuals, e.g. a personal website, groups e.g. a project workspace and communities, e.g. an online encyclopedia. One of the most famous wikis is Wikipedia which is a community-based online encyclopedia run on the Mediawiki engine. This thesis highlights the use of the wiki as a CT in the educational context. In essence, it is an “academic wiki” which was coined by Elgort (2007) to describe wikis that incorporate elements of the social Web, a group project tool and an academic study tool.

Academic wikis are suitable tools for collaborative learning. Case study findings by Koh and Lim (2007) suggests that the critical success factors in online learning are the need for peer interaction, ease of access to learning materials, wide range of resources, ease of knowledge sharing, flexibility in time/space of study, instructor support and degree of engagement. Wiki technology fulfills these requirements. For instance, the wiki affords students flexibility in the time of study as it is an asynchronous web-based medium. Students do not have to be online at the same time in order to interact. Rather, they leave messages for each other and the receiver checks the new input when it is convenient for him/her to go online to view it.

Moreover, these CTs facilitate the collaborative writing of documents. They enable all members of a group to access the central document, ensuring no duplication of work, at the

member's own time and place. In addition, wikis are able to facilitate both the process and outcome of communication (Fuchs-Kittowski & Köhler, 2005). For instance, content management systems center on the transfer of outcomes between various people and restrict the process of communication to annotation while discussion boards tend to focus on the cooperation process such as the exchange of opinions and are limited in the formation of the collaborative result. In contrast, wikis allow students to gather disparate information and come to a common understanding (the process); at the same time, students can work toward integrating the information into a coherent document (the output).

The flexibility of wikis applies to instructors too, allowing them myriad ways to customize the wiki for their teaching purposes. Wiki engines are also relatively inexpensive as it uses available technology in schools and the software is downloadable for free.

However, there are some limitations of using wikis. One disadvantage of wikis stems from the newness of the media as users are unfamiliar with this technology and are accustomed to "read-only" web-based systems (Raman, et al., 2005). They need time and training to learn how to use the system, although this learning curve is very small. A drawback of the wiki is that some consider the wiki interfaces as ugly (Francescato, et al., 2006). The simple and somewhat chaotic wiki page may disappoint users used to well-designed websites. Still, this can be circumvented by administrators adding more stylistic features to the wiki interface.

3.6.2 Empirical Studies

Three empirical studies are designed. The first study, labeled Study I, and titled "The Interplay of Collaborative Technology with Learner Characteristics: *Foundational* Examinations" introduces the foundational framework for the thesis. Anchoring upon and informed by the existing literature, two CT characteristics – sociability and visibility, and two learner characteristics – gender and age, are focused on. The study proposes that the input characteristics will have a direct impact on learning outcomes, consisting of academic achievement, self-reported learning, solution satisfaction, process satisfaction, and positive

social environment. In addition to the direct relationship, an interacting relationship between the CT dimension, learner dimension and learning outcomes is proposed. For instance, the age of the leaner will moderate the effect of sociability on learning outcomes. A quasi-experiment will be conducted in a blended learning course in higher education that will be utilizing CTs (Mediawiki and Wetpaint). This first study sets the groundwork in examining the interplay between CT characteristics and learner characteristics to investigate the effectiveness of CTs for learning groups.

The second study, Study II, titled "The Interplay of Collaborative Technology with Learner Characteristics: *Process* Examinations" establishes the interaction process in learning groups. It aims to address a visible gap in research by examining the communication processes that happen while teams operate i.e. task-related and socio-emotional activities. In addition, the study pays attention to several inputs highlighted as salient previously: learners' prior wiki experience, instructor support, age, and gender. In this study, the research proposes that wikis positively affect learning performance (academic achievement, self-reported learning, and process satisfaction) and socio-related outcomes (positive social environment and a sense of community), through the processes of task-related and socio-emotional activities. Wiki experience, instructor support, age and gender are inputs hypothesized to enhance the communication activities. Using the survey methodology, the model will be tested using two separate wikis (Mediawiki and Confluence) with different students over a protracted period of one semester in a course in higher education. This study follows the I-P-O approach and highlights the importance of two key communication processes, task-related and socio-emotional activities.

The third and final study, Study III, is titled "The Interplay of Collaborative Technology with Learner Characteristics: *Interactional* Examinations". It builds on the previous two studies by integrating inputs and communication processes. For the CT dimension, CT sociability is examined. For the learner dimension, proximity is investigated. Similar to Study I, this study proposes a direct and moderating effect of the characteristics on learning outcomes. Learning

outcomes examined are academic achievement, self-reported learning and positive social environment. Furthermore, the study extends the communication process in Study II and conceives of a task-related and socio-emotional activity balance. The study proposes that a balance of these two communication activities will affect learning outcomes. Moreover, this balance will moderate the relationship between CT sociability and learning outcomes. In the same vein, the communication activity balance will moderate the relationship between proximity and learning outcomes. A quasi-experiment with learning groups comprising students from Singapore and the United Kingdom will be carried out. Two CTs are developed: We-Key and Co-Wiki, to investigate the effectiveness of CTs. In sum, Study III provides a further understanding of the role of task-related and socio-emotional activities in the social context of CT sociability and proximity, two key input characteristics, and its relationship with learning outcomes.

The conduct of the three studies is reported in the following chapters.

Chapter 4: Study I - The Interplay of Collaborative Technology with Learner Characteristics: Foundational Examinations

4.1 Introduction

In recent years, developments in the IT consumer industry have seen a shift from offline software to online software services. One of the forefronts of this trend is a new breed of CT that includes wiki-based software such as PBWorks™, Wetpaint™, and Mediawiki. These are based on cloud computing software services and allow the editing of documents online where each revision of the document is tracked. More importantly, these applications turn individual document creation into group workspaces in which project teams can co-author a single document. Some of these applications even add functionalities which could potentially enhance the sociable experience of users. For instance, features such as user profiles, group chats, and task schedulers, could potentially augment informal and formal interaction among team members.

Besides facilitating team-based collaboration, these CTs also provide the ability for documents to be shared with other individuals. Using a public mode of visibility, teams can share their work on the World Wide Web with members of the public. In education, these technological designs could affect the learning group's interaction and even enhance the learning outcomes for learners (Cress & Kimmerle, 2008; Wang, 2010).

This suggests that two characteristics of CT could affect learning outcomes: CT sociability and CT visibility. CT Sociability refers to the extent that technology facilitates the emergence of a sound social space in which healthy social relationships among group members are formed, as seen in group norms, roles, and beliefs (Kreijns, et al., 2007). The sociability of these technologies could embed new ways for collaborating online (Laurillard, 2009) and affect desired outcomes in education (Chou & Min, 2009). CT visibility concerns the different modes of access for group workspaces. CTs provide a private mode, i.e. access only to team members, and a public mode, i.e. the ability to share the workspace with other members of the

public. In the public mode of visibility, the transparency of the collaboration process could affect the learner's collaboration and outcomes (Guth, 2007).

In addition, as technology features do not exist in silos, the study will also examine learner characteristics. Gender and age are salient factors that have been examined in the literature. These learner characteristics have affected learning outcomes in past CT implementations (Hong, 2002; Prinsen, et al., 2007). It is crucial to examine these learner characteristics in the light of new breeds of CT. Moreover, rather than viewing inputs in relative isolation, the study will also examine the interaction effect of the technology and learner dimensions, which is consistent with past perspectives (Gladstein, 1984; Hinds & Mortensen, 2005; Sharda, et al., 2004; Terborg, 1981).

Based on theoretical frameworks including Piccoli et al. (2001) and Sharda et al. (2004), the study will examine two dimensions of interest, the technology and learner dimensions on the effectiveness of CTs for learning groups. CT effectiveness is determined by the learning outcomes of self-reported learning, academic achievement, solution satisfaction, process satisfaction and positive social environment. The research question is, how does the interplay of CT characteristics (sociability and visibility) and learner characteristics (gender and age) affect learning outcomes?

This question will be empirically examined in a longitudinal field experiment utilizing the wiki as the CT of focus for a group assignment among 235 undergraduates. The next section describes the research model and the hypotheses. Subsequently, the research methodology will be delineated on followed by the data analysis and results. Next, the empirical results are discussed after which the implications of the findings and concluding remarks for Study I are elaborated on.

4.2 Research Model and Hypotheses

Piccoli et al. (2001) delineated two key dimensions in technology-mediated learning effectiveness, the technology and learner dimensions. For this study, the paper concentrates on two CT characteristics, sociability and visibility that fall under the technology dimension. For the learner dimension, gender and age will be examined. As suggested by past research, learning outcomes investigated are self-reported learning, academic achievement, solution satisfaction, process satisfaction, and positive social environment (Bloom, 1956; Hew & Cheung, 2009; Tyran & Shepherd, 2001).

Consistent with the functional perspective (Wittenbaum, et al., 2004), the research proposes that input dimensions, CT characteristics and learner characteristics directly impact learning outcomes. In addition to a direct relationship between the characteristics and learning outcomes, past research has theorized that the learner dimension interacts with the technology dimension to affect outcomes (Sharda, et al., 2004; Terborg, 1981). A two-way dynamic occurs between factors to affect outcomes (Terborg, 1981). Indeed, no matter how good the design of the CT, individual differences can affect the effectiveness of CT. The study thus proposes to examine the moderating effect of the learner dimension on the relationship between the technology dimension and learning outcomes. The research model is illustrated in Figure 4.1. The following paragraphs elaborate on the research hypotheses.

CT sociability could affect learning outcomes. Basically, systems can be categorized into high and low sociability. High sociability could encourage more communication and collaboration among online learners (Boyd, 2007). For instance, having a purposefully designed group chat room for the project task on the application would encourage members of the group to utilize that area to discuss about the task at hand. In addition, it would allow the members to easily communicate with other members when members were online at the same time. Such high sociability allows spontaneous information sharing and task discussion which would enhance the cognitive performance of learners (Cress & Kimmerle, 2008; McLoughlin & Lee, 2007). Moreover, higher interaction among learners would enhance the self-reported learning of students (Arbaugh & Benbunan-Fich, 2007).

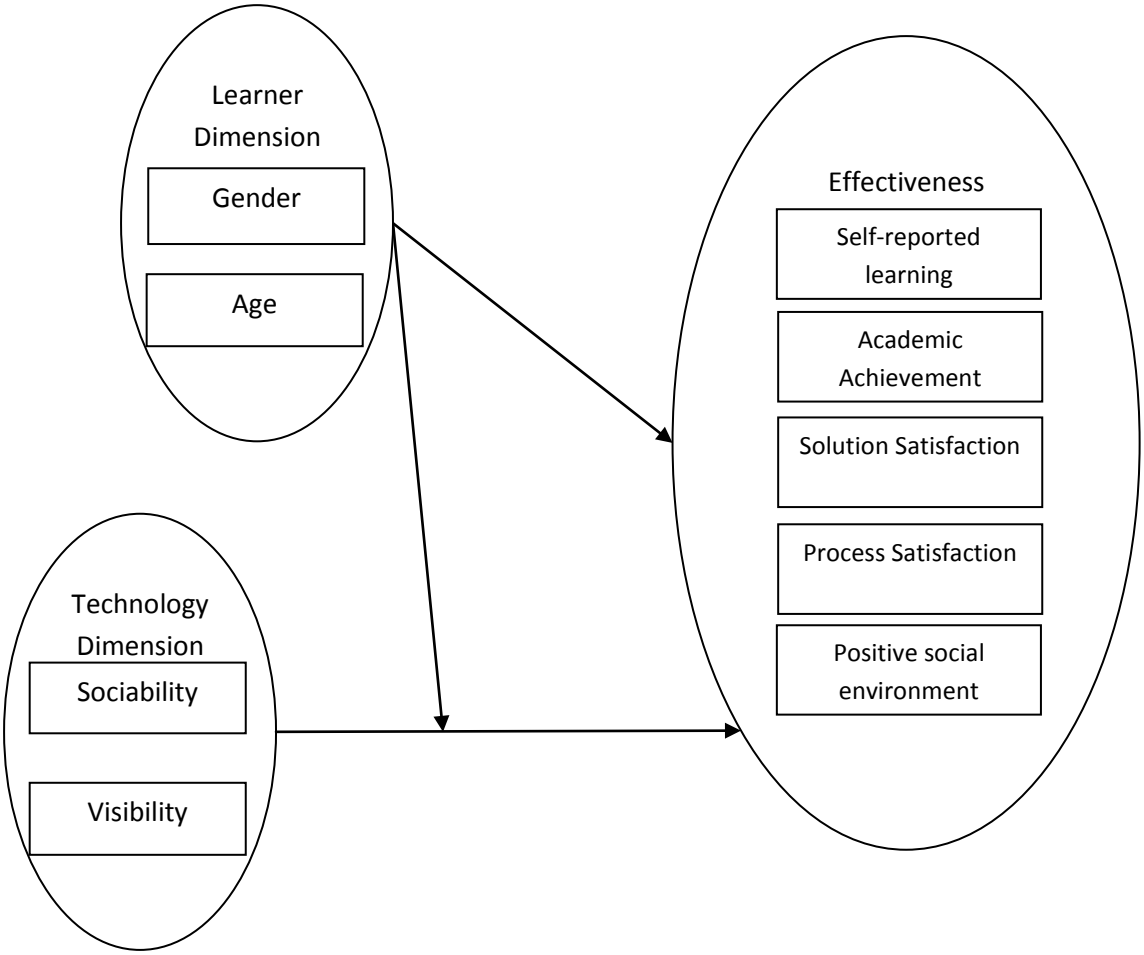


Figure 4.1 Research Model

Systems with high sociability should also encourage informal conversation, social feedback and rapport which would strengthen the relationships among the group. For example, having a user profile and a record of activity like last logins of fellow learners could enhance the feelings of comradeship and togetherness of the group. The feelings of solidarity, care and concern for each other will enable students to work together cohesively in a group. This higher sociability will give rise to higher satisfaction for the process and outcome, and a better social environment (Kreijns et al., 2007; McLoughlin, & Lee, 2007). Moreover, greater breadth and depth of information sharing as brought about by higher sociability led to learner satisfaction and a positive social environment in a field study of 123 students divided into 16 groups (Chou, & Min, 2009). This leads us to five hypotheses:

H1: High sociability increases (a) self-reported learning, (b) academic achievement, (c) solution satisfaction, (d) process satisfaction and, (e) positive social environment.

The visibility of CT could affect learning outcomes. Earlier education research on audience analysis and writing publication on the Internet reveal that students perform better academically as they write to communicate with an audience as compared to demonstrating their skill to the teacher (Cohen & Riel, 1989). By providing an intrinsically meaningful context of learning and a distant audience, the public mode of visibility of CT increases student motivation and participation (Bruns, & Humphreys, 2007). This should increase learner's self-reported learning and academic achievement. Moreover, learners could be more careful of what they write and verify the accuracy of their points and facts before displaying it to the Internet audience. Putting greater effort into the project task would result in learners being satisfied with the resultant solution.

However, the public accessibility of CT could also cause users to be concerned of what they should reveal to others. Iachello and Hong (2007) note the tension between privacy and social transparency in many emerging social technologies. In the public mode of visibility, students are concerned over the identity of the audience, divulge less personal information and limit their communication (Karsten, 2003). On the other hand, in the private mode, students have less concern for privacy and more ownership of the task. They easily share information, give feedback, and encourage the team. This implies that in the public mode of visibility, students could be less satisfied with the process of the project and perceive a less positive social environment compared to the private mode of visibility.

Initial evidence supports this stand. In an action research project, Guth (2007) compared between the two modes of visibilities using a wiki. The research found student work quality higher in the public wiki compared to a private wiki. Moreover, public visibility led to a lower sense of ownership as students were uncomfortable with sharing the project with other

audiences. For the private wiki, students had more control and felt a stronger sense of community and were able to express themselves freely. The hypotheses are:

H2: Public visibility increases (a) self-reported learning, (b) academic achievement, (c) solution satisfaction but decreases (d) process satisfaction, and (e) positive social environment.

Gender has the potential to affect learning outcomes. Two main perspectives account for gender differences - task and relationship orientation (Hahn & Litwin, 1995) and gender-role socialization and stereotypes (Kray, Galinsky, & Thompson, 2002) The former suggests that men are task-oriented while women are relationship-oriented, the latter posits that gender roles arise from socialization i.e. males and females learn these roles from society since they were young.

As females are more relationship orientation and want to feel connected with others, they should be more satisfied with the collaborative process and solution, and also perceive a positive social environment compared to males. The socialization perspective reinforces the desire for females to be collaborative while males tend to be competitive. Moreover, online communication allows egalitarian participation, reducing the dominance of a particular person, allowing more females to communicate. This could further increase the satisfaction and the positive social environment for females. Empirical support for higher satisfaction and a more positive social environment for females has been demonstrated (Jeffrey, 2009; Lind, 1999; Ocker & Yaverbaum, 2001; Swan, et al., 2000).

In terms of cognitive learning, there is no conclusive evidence of male or female superiority. Although Swan et al. (2000) find that females reported higher self-reported learning, other studies find no differences in cognitive gain among males and females. This study believes that although males and females are different and may have different computer-mediated communication styles, they are able to learn just as well using their different orientation or socialization. Thus the paper predicts:

H3: There will be no differences among males and females for (a) self-reported learning, (b) academic achievement, but females will perceive higher levels of (c) solution satisfaction, (d) process satisfaction and, (e) positive social environment than males.

The age of learners could affect learning outcomes too. To a certain extent, the socio-constructivist approach to learning dovetails with the skills required in technology-mediated learning which is that learners need to be active and independent thinkers, participating in group discussion and utilizing technological tools at their own volition (Leidner & Jarvenpaa, 1995; Vygotsky, 1978). According to developmental theories, older individuals tend to be more self-motivated, disciplined and also have wider life experiences (Harter, 1999). These help them cope with the demands of technology-mediated learning. Although younger individuals can adapt quickly to new technology, they may not have the skills and strategies to engage in collaborative learning. Thus, the study predicts that older learners would have better learning outcomes than younger learners. This has been shown in a study by Swan et al. (2000) where 1406 students enrolled in the SUNY learning network were surveyed.

H4: The older the learner the higher the (a) self-reported learning, (b) academic achievement, (c) solution satisfaction, (d) process satisfaction, and (e) positive social environment.

Learner characteristics could affect the effectiveness of the technology deployed. Firstly, the relationship between the sociability of the system and learning outcomes could be moderated by gender. Applications with high sociability applications provide support for informal conversations and connections among others. This is in line with the female orientation who desired collaboration with others as compared to the male orientation which can be argumentative and competitive. Thus, relationship between high sociability, process satisfaction, solution satisfaction and positive social environment could be stronger for females than males. On the other hand, gender should not affect the relationship between sociability and self-reported learning and academic achievement. Although sociability should enhance the task discussion among the team, both males and females equally participate in

online discussions which contribute to their cognitive learning (Phadtare, et al., 2009). The paper therefore suggests:

H5: The relationship between sociability and (a) self-reported learning, (b) academic achievement will not be moderated by gender but the relationship between sociability and (c) solution satisfaction, (d) process satisfaction, and (e) positive social environment will be moderated by gender: that is, the relationship is stronger for females than males.

Secondly, the relationship between the sociability of the system and learning outcomes could be moderated by age. In conditions of high sociability, learners can more easily engage in spontaneous discussion with their team members. On the one hand, this may be welcomed by older learners as they can learn more. On the other, it may also be unpleasant for older learners as they tend to be more time-pressed and prefer to concentrate on the task. These informal discussions may be seen as a non-efficient usage of time by them. Nevertheless, in line with the earlier argument, older learners tend to possess a greater ability to cope with the necessities of technology-mediated learning. The sociability of the system could also provide avenues for older learners, who are more mature, to deepen the conversation, which would enhance their cognitive outcomes. As a result, the building of bonds for older learners could be enhanced too. Thus, the research hypothesizes:

H6: The relationship between sociability and (a) self-reported learning, (b) academic achievement, (c) solution satisfaction, (d) process satisfaction, and (e) positive social environment will be moderated by age: that is, the relationship is stronger for older learners than younger learners.

Thirdly, visibility could also be affected by learner characteristics. Earlier, the paper predicted that gender would not affect cognitive outcomes, similarly, public visibility will not affect this relationship either. Still, the gender of learners could moderate the influence of visibility on learning outcomes. Females desire connections with others, more so, compared to men, who tend to prefer personal cognitive journeys (Jeffrey, 2009). As public visibility allows

connections to external audiences, not just the internal team, it implies that females would want to ensure a good solution i.e. they will have higher solution satisfaction in the public mode compared to males. As for process satisfaction and positive social environment, earlier research suggests that while females tend to be more satisfied with online collaboration, yet the public mode of visibility limits the degree of comfort females have with the collaboration process. Under the glare of the Internet public, females may reduce their information sharing and contribution which would lower their process satisfaction and their opinions of a positive social environment. This suggests that there is no moderating effect between gender and process satisfaction and positive social environment.

H7a) and b): There will be no relationship between visibility and gender for (a) self-reported learning and (b) academic achievement.

H7c): The relationship between visibility and solution satisfaction will be moderated by gender, that is the relationship is stronger for females than males.

H7d) and e): There will be no relationship between visibility and gender for (d) process satisfaction and (e) positive social environment.

Fourthly, visibility could be moderated by age. Younger users are typically more accustomed to social technology and are less concerned about the implications of public visibility. Bruns and Humphreys (2007) report that young undergraduates had an adroit cynicism toward public visibility; they did not think that other audiences would view their work online. On the other hand, due to their wider experiences and closeness to the workforce, older learners could be more concerned about their privacy and would limit their participation in public spaces. This implies that younger learners would still participate actively, discuss, negotiate, and have informal conversations in the public sphere. Thus, the paper predicts that the public mode of visibility will enhance learning outcomes more for younger learners than older learners.

H8: The relationship between public visibility and (a) self-reported learning, (b) academic achievement, (c) solution satisfaction, (d) process satisfaction, and (e) positive social environment will be moderated by age: that is, the relationship is stronger for younger learners than older learners.

4.3 Research Design and Methodology

As the focus of the thesis is on learning groups, undergraduate students completing a group project in a course fit the criteria. Moreover, the field experiment methodology was selected. Although suffering from less control than a laboratory experiment, a field experiment enables the subjects to be immersed in an authentic learning environment which will increase external validity and reduce evaluator apprehension. An introductory course to Computing, for undergraduates from various faculties except Computing and Engineering faculties at a large university in the Asia-Pacific.in the campus, was selected. The reasons for the course selection were that the lecturer was keen to integrate the use of CTs in the module as well as the large size of the course intake.

4.3.1 Procedure

The field experiment procedure and the sociability and visibility levels of the different CTs were first pilot tested with 10 students. This fine-tuned the experiment design and also reaffirmed the different levels of sociability of the two systems and their respective visibilities.

The steps of the experiment consisted of three stages: training, group proposal drafting and the actual assignment. Students were first given a 30 minute face-to-face hands-on training session with the CT in tutorial classes. Groups of 4 to 5 were then formed for the course. Students were allowed to form their own groups. Each group was allocated a URL which designated their team workspace. They were instructed to use the workspace to draft and submit a proposal for a project in the course. This first task, group proposal drafting, was

designed to ensure that students gained familiarity with the CT. After the proposal was submitted, a pre-test questionnaire was conducted.

Next, the actual assignment was launched and groups were given 2 weeks to use the CT to write out their answers to the assignment. Students were encouraged to contribute answers, comment on teammate's answers and jointly edit the answers using all the features in the CT. After 2 weeks, students submitted their assignment and answered a post-test questionnaire.

4.3.2 Task

Group members were asked to deliberate on a set of IT-related issues and generate solutions. The experimental task is shown in Appendix A1. It is open-ended without a single solution which encouraged student discussion and interaction on the CT. The assignment was related to the course content. It was worth 5% of the students' continual assessment, which ensured that students put sufficient effort into completing it. Although students were not stopped from meeting face-to-face, they had to use the CT to submit their assignment. A check of the CT logs revealed that all students accessed the system and provided input in the team workspace.

4.3.3 Experimental Manipulation

Two CTs were chosen to represent high and low sociability (SOC). Mediawiki was selected for low sociability while Wetpaint for high sociability. The Mediawiki system had a simple main page and a discussion page. On the other hand, Wetpaint had a main page, a chat page, user profile pages where students could add a photograph, a comment section and a like button for comments. The screenshots of the two wikis are shown in Figure 4.2 and Figure 4.3. Both applications also allowed private or public visibility and had the basic group authoring functionality. In addition, the visibility (VIS) level of the CT was worded into the task instructions for each team workspace. This differed for each workspace according to the workspace they were randomly assigned to. Groups assigned to a private workspace were informed that only logged-in members of the team could view, edit and add new pages while

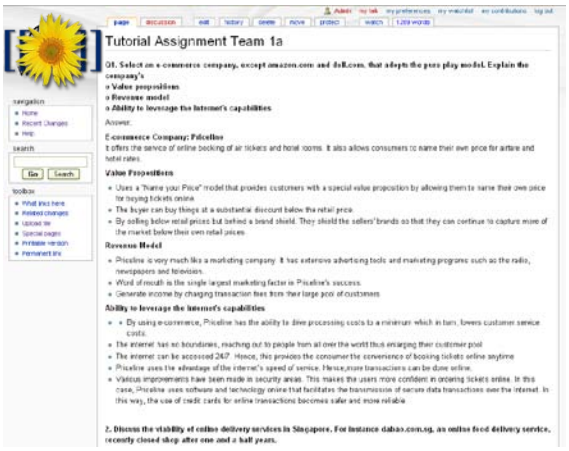


Figure 4.2 Mediawiki Screenshot

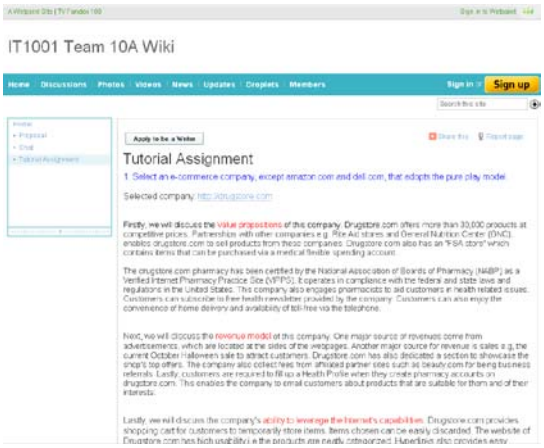


Figure 4.3 Wetpaint Screenshot

those allocated to a public workspace were told that their workspace allowed non-logged-in members to view the site, but not edit it. Although the design of the two wikis was not controlled, the content for each workspace was the same; as the text was populated via templates.

4.3.4 Measurement Instruments

Measures of the variables were developed based on previous literature except for VIS which was self-developed. The scales were previously sorted by 5 senior graduate students. Ambiguous items were improved or discarded; this ensured that the items had sufficient face validity. The pre-test questionnaire collected demographic data including gender (GEN) and age (AGE). It also measured group history; students were asked to specify their prior relationship with each member of their group. Lastly, SOC and VIS were measured. SOC scales were based on Kreijns et al. (2007) while VIS had one item. The measurement of these constructs served as a manipulation check for each experimental condition.

The post-test questionnaire measured self-reported learning (SRL), solution satisfaction (SSA), process satisfaction (PSA), and positive social environment (PSE), and other qualitative feedback. SRL was taken from Alavi (1994) while SSA and PSA scales came from Green and Taber (1980). PSE was based on Kreijns et al. (2007). These scales were measured on a seven-point Likert-type scale. All items are displayed in Appendix A2. The academic performance (ACA) of

each group's assignment was graded by three staff who were subject experts. The marking criteria evaluated the quality of the answers for accuracy, clarity, organization and teamwork. As much as possible, the judges were blind to the experimental design.

4.4 Data Analysis and Results

There were a total of 235 students taking the course forming 62 groups. However, not all students completed the questionnaire. After filtering the invalid responses, there were 141 usable responses. Consistent with the approach of other studies which examine the individual's perceptions of the group (Hoyle & Crawford, 1994; Jarvenpaa, Shaw, & Staples, 2004), data was analyzed at the individual level. Moreover, the research was interested in the individuals' perceptions of the group rather than the group level perception. Partial least squares (PLS) analysis was utilized to test the significant relations among the variables. PLS does not have distributional assumptions of data normality and is able to handle small-to medium-sized samples (Chin, 1998).

Table 4.1 shows the number of subjects in each condition and their respective means and standard deviations for all the variables of interest. The average age of the students was 21.18 ranging from 18 to 26. They had an average Internet experience of 8.78 years and were mostly in the second year of their university studies. There were 56 males and 85 females. One-way ANOVAs at 0.05 level of significance revealed no significant difference between group history and any of the learning outcomes. There was a significant difference between the sociability of the two applications, $F=5.820$, $p=.017$ and between the two modes of visibility, $F=4.284$, $p=.040$. This suggests that the manipulation was successful between the conditions. Measured using a 7-point Likert scale, the average sociability for Mediawiki was 3.86 (Std. deviation 0.90) while the average sociability for Wetpaint was 4.21 (Std. deviation 0.84). On the other hand, the average

private visibility was 4.26 (Std. deviation 1.13) while the public visibility was 4.69 (Std. deviation 1.30).

Table 4.1 Means and Standard Deviations for Variables examined

SOC	VIS	GEN		AGE	SRL	ACA	SSA	PSA	PSE
Low Sociability	Private	Male N=18	Mean	20.67	4.82	3.86	5.93	5.56	4.81
			Std. Deviation	1.24	1.12	0.68	0.66	0.78	1.40
		Female N=27	Mean	21.30	5.12	4.02	5.31	5.18	5.16
			Std. Deviation	1.46	0.96	0.62	0.85	0.86	1.05
		Total N=45	Mean	21.04	5.00	3.96	5.56	5.33	5.02
			Std. Deviation	1.40	1.03	0.65	0.83	0.84	1.20
	Public	Male N=9	Mean	20.44	4.67	4.00	5.78	5.67	4.81
			Std. Deviation	1.59	1.03	0.50	0.80	0.83	1.36
		Female N=16	Mean	21.19	5.13	3.94	5.75	5.27	5.20
			Std. Deviation	1.76	1.29	0.87	0.76	0.97	1.03
		Total N=25	Mean	20.92	4.96	3.96	5.76	5.41	5.06
			Std. Deviation	1.71	1.20	0.75	0.75	0.92	1.15
	Total	Male N=27	Mean	20.59	4.77	3.91	5.88	5.59	4.81
			Std. Deviation	1.34	1.08	0.62	0.70	0.78	1.36
		Female N=43	Mean	21.26	5.12	3.99	5.48	5.21	5.18
			Std. Deviation	1.56	1.08	0.72	0.83	0.89	1.03
		Total N=70	Mean	21.00	4.99	3.96	5.63	5.36	5.03
			Std. Deviation	1.50	1.08	0.68	0.80	0.86	1.17
High Sociability	Private	Male N=11	Mean	21.36	5.22	3.41	5.91	5.73	5.66
			Std. Deviation	1.50	0.78	0.44	0.68	0.74	0.80
		Female N=26	Mean	21.85	4.88	3.58	5.46	5.46	5.48
			Std. Deviation	1.89	1.10	0.37	0.78	0.79	0.74
		Total N=37	Mean	21.70	4.98	3.53	5.59	5.54	5.53
			Std. Deviation	1.78	1.02	0.39	0.77	0.78	0.75
	Public	Male N=18	Mean	21.39	5.29	3.56	5.83	5.57	5.61
			Std. Deviation	1.24	0.78	0.64	0.72	0.65	0.52
		Female N=16	Mean	20.50	5.13	3.44	5.75	5.67	5.36
			Std. Deviation	1.10	0.86	0.60	0.54	0.62	0.77
		Total N=34	Mean	20.97	5.21	3.50	5.79	5.62	5.49
			Std. Deviation	1.24	0.81	0.62	0.63	0.63	0.65
	Total	Male N=29	Mean	21.38	5.26	3.50	5.86	5.63	5.63
			Std. Deviation	1.32	0.77	0.57	0.69	0.68	0.63
		Female N=42	Mean	21.33	4.98	3.52	5.57	5.54	5.43
			Std. Deviation	1.75	1.01	0.47	0.71	0.73	0.75
		Total N=71	Mean	21.35	5.09	3.51	5.69	5.58	5.51
			Std. Deviation	1.58	0.93	0.51	0.71	0.71	0.70

The direct relationship between the independent variables and dependent variables was first modeled as suggested by the literature (Wilson, 2010). Tests to the measurement model revealed adequate reliability, convergent validity and discriminant validity. Although the correlation between PSA and SSA were high, >0.7, cross loadings of each latent variable correlation were an order of magnitude larger for its theoretically assigned measurement item compared to the other

items which is a criteria for discriminant validity (Gefen & Straub, 2005). The measurement model results are shown in Table 4.2.

For the structural model, the main effects and interaction model was tested (Table 4.3). As can be seen the interaction model increases the R-squared values of all the dependent variables by at least 1.6% with the highest increase of 7.5% for ACA. The interaction model revealed that ACA could explain 15.8% of the variance, SSA 10.9%, PSE 9.8%, PSA 7.4 % and SRL 3.6%, arranged in order of magnitude. This indicates that the model has predictive validity for ACA and SSA but less so for PSE, PSA and SRL. Fifteen hypotheses were supported. The next section discusses the results.

Table 4.2 Measurement Model Results

	CR	α	AVE	SOC	VIS	GEN	AGE	SRL	AP	SSA	PSA	PSE
SOC	1.000	1.000	1.000	**1.000**								
VIS	1.000	1.000	1.000	*0.123*	**1.000**							
GEN	1.000	1.000	1.000	*-0.023*	*-0.105*	**1.000**						
AGE	1.000	1.000	1.000	*0.114*	*-0.126*	*0.093*	**1.000**					
SRL	0.964	0.953	0.842	*0.089*	*0.08*	*-0.020*	*0.077*	**0.918**				
ACA	1.000	1.000	1.000	*-0.249*	*-0.004*	*0.002*	*0.108*	*0.267*	**1.000**			
SSA	0.913	0.856	0.778	*0.082*	*0.149*	*-0.221*	*-0.005*	*0.555*	*0.331*	**0.882**		
PSA	0.927	0.885	0.809	*0.148*	*0.068*	*-0.131*	*0.058*	*0.530*	*0.344*	*0.748*	**0.899**	
PSE	0.920	0.884	0.741	*0.263*	*0.057*	*-0.003*	*0.111*	*0.643*	*0.300*	*0.660*	*0.691*	**0.861**

Notes: CR= Composite Reliability, α = Cronbach's Alpha, AVE= average variance extracted, Italics = Correlations between constructs, Bold = square root of AVE

4.5 Discussion

The direct impact of SOC on learning outcomes was supported for PSA and PSE. High SOC increased PSA and PSE which indicates that having a more sociable application allows the team to have a greater sense of togetherness and build the team bonds. The process of doing the assignment is also more enjoyable as there are more avenues to interact. As for SSA, learners in low and high SOC were relatively satisfied with their group assignment (means of 5.63 and 5.69 respectively). This result is similar to findings in other studies comparing SSA across different media (Benbunan-Fich, 1999). The means for SSA were highest across all outcomes and suggest

Table 4.3 Structural Model results

Structural relation		Model 1 (Main effects)		Model 2 (Interaction model)		Hypothesis Supported?
		Path Coeff	t-Value	Path Coeff	t-Value	
Design Dimension						
H1a	SOC→ SRL	0.069	0.933	0.076	1.112	No
H1b	SOC→ACA	-0.272***	3.384	-0.293***	3.576	No, sig. opp. direction
H1c	SOC→ SSA	0.059	0.804	0.074	1.146	No
H1d	SOC→ PSA	0.133	1.597	0.145**	2.210	Yes
H1e	SOC→ PSE	0.248***	4.247	0.247***	4.406	Yes
H2a	VIS → SRL	0.086	1.143	0.060	0.791	No
H2b	VIS → ACA	0.046	0.655	2.071**	2.614	Yes
H2c	VIS → SSA	0.122*	2.159	0.127*	1.988	Yes
H2d	VIS → PSA	0.046	0.617	0.052	0.718	No
H2e	VIS → PSE	0.037	0.509	0.011	0.147	No
Human Dimension						
H3a	GEN !→ SRL	-0.017	0.260	-0.029	0.416	Yes
H3b	GEN !→ ACA	-0.013	0.183	-0.062	0.928	Yes
H3c	GEN → SSA	-0.209***	3.657	-0.231***	3.923	No, sig. opp. direction
H3d	GEN → PSA	-0.128	1.584	-0.134^	1.834	No
H3e	GEN → PSE	-0.002	0.023	-0.021	0.292	No
H4a	AGE → SRL	0.082	1.217	0.073	1.075	No
H4b	AGE → ACA	0.146**	2.598	0.273***	4.168	Yes
H4c	AGE → SSA	0.023	0.263	0.051	0.651	No
H4d	AGE → PSA	0.060	0.695	0.084	1.032	No
H4e	AGE → PSE	0.088	1.246	0.084	1.216	No
Interaction construct/term						
H5a	SOC*GEN !→ SRL			0.069	1.038	Yes
H5b	SOC*GEN !→ ACA			0.125	1.855	Yes
H5c	SOC*GEN → SSA			-0.072	0.952	No
H5d	SOC*GEN → PSA			-0.113	1.525	No
H5e	SOC*GEN → PSE			0.058	0.914	No
H6a	SOC*AGE→ SRL			-0.034	0.499	No
H6b	SOC*AGE → ACA			-0.257***	4.821	No, sig. opp. direction
H6c	SOC*AGE → SSA			-0.094	1.301	No
H6d	SOC*AGE → PSA			-0.095	1.389	No
H6e	SOC*AGE → PSE			-0.129*	1.941	No, sig. opp. direction
H7a	VIS*GEN !→ SRL			0.067	0.933	Yes
H7b	VIS*GEN !→ACA			-0.059	0.886	Yes
H7c	VIS*GEN → SSA			0.149**	2.314	Yes
H7d	VIS*GEN !→PSA			0.082	1.151	Yes
H7e	VIS*GEN !→PSE			0.015	0.199	Yes
H8a	VIS*AGE → SRL			-0.050	0.689	No
H8b	VIS*AGE→ ACA			-2.040**	2.594	Yes
H8c	VIS*AGE→ SSA			-0.021	0.296	No
H8d	VIS*AGE → PSA			-0.010	0.129	No
H8e	VIS*AGE→ PSE			-0.028	0.389	No
Dependent Variables		R^2		R^2		
SRL		0.020		0.036		
ACA		0.083		0.158		
SSA		0.069		0.109		
PSA		0.043		0.074		
PSE		0.077		0.098		

Notes: bootstrapping results (n=400), *** denotes p<.001, **, p<.01 and *, p<.05. Path Coeff = Path coefficient, sig. opp. direction = significant in the opposite direction.

that CTs in general enable students to complete their assignments and have a positive attitude of the final result.

SOC did not affect SRL as predicted. In general, SRL was non-significant across all the conditions. While this may seem surprising at first, it suggests that learners perceive that they are able to gain knowledge irrespective of system design, gender and age. Moreover, as this was a subjective measure taken after the completion of the assignment, students might have wanted to show their instructor that they had gained knowledge from the project. SOC's relationship with ACA was found to be significant but in the opposite direction. This indicates that high SOC led to lower ACA. A possible reason is that social features such as group chat could have led to idle chatter, rather than task discussion. Other social functions of the application could have also distracted students from the task. Moreover, too much information sharing could have led to information overload which hinders learners from organizing and synthesizing each others' points (Chou, & Min, 2009).

For VIS, H2b and H2c were supported. Public VIS improved ACA and SSA as hypothesized. While affecting the end result, VIS did not affect the process of collaboration or the social environment. It seems learners did not feel more discomfort collaborating in the public mode as adroit cynicism occurred. Learners were skeptical that members of the public would actually view their wiki among the millions of websites on the World Wide Web and thus proceeded to collaborate unaffected by the impact of public VIS. This is a similar to qualitative findings by Forte and Bruckman (2006).

Both genders performed equally well in terms of cognitive outcomes as predicted. Interestingly, males were more satisfied with the solution than females. H3c was significant in the opposite direction from predicted. Although females are more relationship-orientated and enjoy collaborating with others, they did not feel satisfied with the final solution. This could be because

females tend to be accommodating, are more agreeable and engage in less conflict than males in online communication (Lind, 1999; Thomson, 2006). Consequently, the final result may not be a reflection of their initial thoughts, but rather, a suboptimal solution to ensure conformity and peace within the group. Males on the other hand, tend to be more competitive and aggressive and in developing the final solution, would ensure that their thoughts and opinions are included. As a result, the men are more satisfied with the solution than the women. In another surprising finding, gender did not affect PSA and PSE. Earlier research suggests that participation equality for females enhanced their PSA and PSE (Ocker, & Yaverbaum, 2001). However in the current context, female learners are used to egalitarian participation and this did not make a difference in their collaboration process, resulting in similar PSA and PSE as males.

As for age, only H4b was supported. Older students had higher ACA than younger students as predicted. For the other hypotheses, age was non-significant indicating that younger learners due to their familiarity with online collaboration systems were similarly satisfied with older learners on the solution, the collaboration process and, the social environment. Further explanation for the effects of gender and age can be seen through the interaction hypotheses.

The interaction of SOC and gender did not affect cognitive outcomes as hypothesized. Higher SOC did not result in higher PSA, SSA or PSE for females as predicted (H5c, H5d, and H5e). Although females prefer to work with others, in the case of a group task, where the learners are forced to work together, the SOC of the system assists both genders to communicate and collaborate with their teammates. Furthermore, this suggests that the SOC of the system is regarded in the same way by both genders and is gender-neutral.

The results for the hypotheses on the interaction of SOC and age reveal a significant negative relationship, which is opposite to what this research predicted. Moreover, H6b for ACA and H6e for PSE were significant in the opposite direction. These suggest that learning outcomes will be

better for younger learners with high SOC. A plausible explanation is that the generation perspective argument is in play; the younger generation of learners are embracing these new collaborative systems, which facilitate their ACA and allows them to experience a positive learning climate. Moreover, it could be because younger individuals are more keen to engage in new experiences compared to older individuals (Harter, 1999) and these applications afford them new collaborative experiences which translates into better outcomes for them.

As for the interaction between VIS and gender, all the hypotheses were supported. For SRL and ACA, both genders had similar outcomes in both modes of VIS. For SSA, the data reveals that females using applications with public VIS were more satisfied. It supports the argument that females, who enjoy connecting with others, feel rewarded for writing an assignment for a wider Internet audience. As for PSA and PSE, the data was non-significant as predicted. Earlier research suggests that females tend to be more satisfied with online collaboration yet the public mode of VIS limits the degree of comfort females have with the collaboration process resulting in less sharing and the withholding of personal information. These reasons cancel out the potential effect of gender on outcomes and thus, gender and VIS did not affect PSA and PSE.

Lastly, VIS did have a significant moderating effect for age on outcomes. H8b was significantly different in the direction predicted. Younger learners had higher ACA using CT with public VIS implying that they could have discussed more as they were not as concerned about their personal privacy as compared to older learners. Nevertheless, non-significant results were found for H8a, c, d, and e, although the path coefficients were in the direction as hypothesized. A possible reason is that younger learners while being less perturbed by the public mode of VIS, were not as mature and able as older learners to handle the challenges of online collaboration and reported equal levels of SRL, SSA, PSA and PSE.

4.6 Implications and Limitations

Both theoretical and practical implications can be derived from the research. While the research has investigated age and gender for the learner dimension, other factors could have been examined, for instance, CT experience and team proximity. Moreover, other learning outcomes, such as those in the psychomotor area e.g. efficiency and response magnitude, could have been examined. Some research has suggested the mediating effects of process variables on the relationship between contextual dimensions and learning outcomes such as participation, exchange of information and cooperation (Tyran, & Shepherd, 2001). These can be examined in future research.

Nevertheless, two design characteristics – SOC and VIS have been delineated. Although these characteristics apply to the context of online collaboration systems, it is possible to conceive them in other web-based contexts, such as social networks, micro-blogging and even web-based email. For example, Facebook and Gmail have both added a chat function, which may conceivably enhance the SOC of the application. Moreover, Twitter and Facebook allow either modes of VIS; it remains to be studied how these differing levels of VIS affect behavior and outcomes.

Practical implications for educators are also suggested. For ACA, the results reveal a relationship between age, SOC and VIS. Firstly, younger students performed better in public VIS while older students did better in private VIS. Secondly, while the results show that high SOC decreased ACA, younger students did better with high SOC and older learners in low SOC. These findings can be illustrated in a cube format which provides a selection rubric for educators where the diagonally shaded boxes indicate the better options for educators (Figure 4.4). In selecting CTs, educators who teach younger learners should select applications with high SOC and also employ a public mode of VIS in order to enhance their ACA. In the case of older learners, educators should select applications low in SOC and employ a private mode of VIS to improve their ACA.

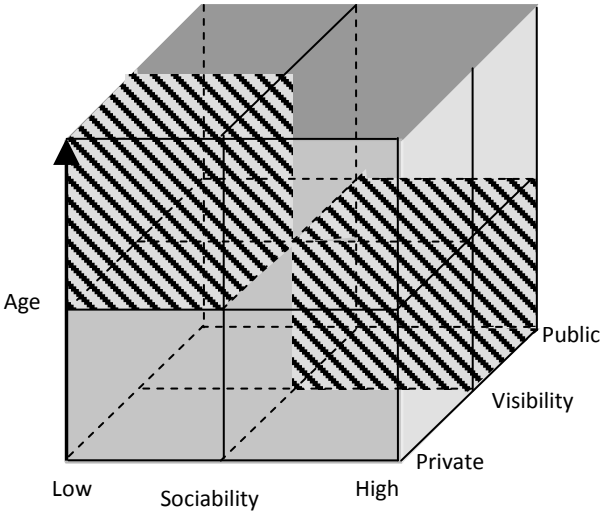


Figure 4.4 Collaborative Technology Selection Rubric to Enhance Academic Performance

The results also suggest that to improve PSE, younger students should use applications high in SOC while older learners should use applications with low in SOC. Thus, if educators want to enhance the social environment for younger students, an application high in SOC should be used. Furthermore, this study has generally found that males have higher SSA than females. Yet, in the public VIS mode, females are more satisfied with the solution than males. This suggests that if educators have a predominantly female class, they should select the public mode of VIS for the application system for higher SSA.

These findings are not without its limitations. The research methodology employed was a quasi-experiment. While providing external validity, the experimenters had no control over the amount of time students used the wiki, and students' face-to-face contact. However, qualitative data collected from the post-test questionnaire indicated that students used the wiki often for their assignment. For instance, a student mentioned, "I used the wiki frequently. I think that it is a good tool that promotes interaction among members. We also used it to upload important information regarding the group project."

Second, there was no randomization of groups. However, the paper measured the team's group history and there was no significant difference between group history and the learning outcomes. For 86% of students, this was the first time they were working with each other. Moreover, groups were sufficiently heterogeneous. The Lieberson diversity index for age and gender were 0.802 and 0.462 respectively.

Moreover, the current setting was for an undergraduate course, and may not be applicable to children or older learners. Despite the said limitation pertaining to the age of learners, the work covers two development periods of adolescence and young adulthood and also the transition age of those born in as well as after 1985. The various perspectives suggest that the findings should be similar for younger and older learners.

4.7 Concluding Remarks

Underpinned by the theoretical frameworks from Piccoli et al. (2001) and Sharda et al. (2004), this paper has developed a research model to understand a new breed of CTs, namely wiki-based collaboration applications. Data revealed a direct and moderating effect of technology and learner characteristics on learning outcomes. This study has shown that higher CT sociability improves PSA and PSE. In turn, the public mode of visibility influences ACA and SSA. Males had higher SSA while increasing age influences ACA. Moderating effects for the relationships between SOC and VIS, and gender and age are also shown.

In sum, the research has shown the saliency of technology characteristics, SOC and VIS, and learner characteristics, gender and age, and their interaction, in CTs. These can enhance learning outcomes of ACA, SSA, PSA, and, PSE. Among the study's contributions, the study is one of the few empirical studies rigorously examining the effectiveness of wiki-based CT. The research therefore adds to the line of research on CT effectiveness.

In addition, several practical implications including a rubric for CT selection for educators have been suggested. This rubric provides guidelines of the type of technology characteristic that is important for better ACA for learners of different age groups.

From a conceptualization of extant literature, this study provides a foundational examination on the effectiveness of new breeds of CT. Mixed support has been shown for the research model. Nevertheless, the key finding is that CT characteristics and learner characteristics affect learning outcomes in a direct and interactive manner. In line with the overall research framework of the thesis, further research will examine other inputs and processes that can affect learning outcomes in wiki-based CTs.

These new breeds of CTs are pivotal technologies that are being adopted en-masse. This research provides theoretical and empirical support for its effectiveness in education which will augur well for future adoption, use and evolution.

Chapter 5: Study II - The Interplay of Collaborative Technology with Learner Characteristics: Process Examinations

5.1 Introduction

Although some studies have examined the relationship between CT characteristics and learning outcomes, an understanding of the processes involved in determining learning outcomes is in want. Several interaction processes occur in small groups, the chief of which is communication (Habermas, 1976). Past research has theorized the importance of communication acts such as the communicative action theory (Habermas, 1976) and the group interaction process (McGrath, 1984). Similarly, this study aims to explore the communication process of the learning group. Moreover, communication has been identified as especially crucial in technology-mediated teams (Powell et al., 2004). Pioneer research by Bales (1950) showed that a group is in a continual state of dividing its time and work between instrumental (task-related) and expressive (socio-emotional) needs. Thus, interacting processes consist of two main types of behavior – task-related and socio-emotional activities. Some studies have expanded the two processes into three processes dividing socio-emotional activities into relating to others and representing the group e.g. the Cognitive three-process model of group interaction (Whitworth, Gallupe, & McQueen, 2000). While differing ways of dissection have been attempted, none deviates from the fundamental task-social perspective.

Research has shown that groups using CT tend to have more task activity (Dubé & Robey, 2008; Jonassen & Kwon, 2001). However, on the flip side, more socio-emotional communication, can also enhance outcomes (Robey, Khoo, & Powers, 2000; Schiller & Mandviwalla, 2007). Moreover, in traditional IS and education research, the social aspect of interaction has been frequently overlooked. The focus is only on task-related activities. For instance, Bonk et al. (1998) referred to socio-related activity as “social acknowledgments” in students’ postings. Moreover, they regarded these interactions as unproductive. A whole stream of CMC research

has also just focused on task-oriented communication while ignoring or discouraging the socio-oriented activities (Chiu & Hsiao, 2010; Heo, et al., 2010; Lipponen, Rahikainen, Lallimo, & Hakkarainen, 2003; Liu, 2002). In an empirical work, Arbaugh and Benbunan-Fich (2006) comment that the social dimension of learning is "essential for the success of online courses, where the sense of the classroom otherwise may be lost" (p.445). In the same vein, this research regards task-related and socio-emotional activities as important for learning outcomes. Viewing one type of interaction alone is insufficient to fully investigate the impact of CT use. To address the visible gap in research, this study will examine the communication processes that happen while teams operate i.e. task-related and socio-emotional activities.

The outcomes of interactions in online collaborative learning can be conceptualized to affect the learning performance and socio-related outcomes of students (Kreijns et al., 2002). Learning performance consists of the domains cognition and affect, and includes academic achievement, self-reported learning, and process satisfaction (Bloom, 1956; Hew and Cheung, 2009). On the other hand, socio-related outcomes deal with feeling, being and relationships. It is a measure of the student's ability to interact with other people and to function in groups. In this study, the socio-related outcomes focused on are a positive social environment and a sense of community (Kreijns et al., 2007; Rovai, 2002; Arbaugh and Benbunan-Fich, 2006).

The key question is: what is the role of task-related activity and socio-emotional activity in affecting learning outcomes using CT? Surrounding this theme the study examines specifically the influence of salient input factors (learners' prior CT experience, perceived instructor support, age and gender) on task-related and socio-emotional activities which affect the learning outcomes of academic achievement, self-reported learning, process satisfaction, positive social environment and sense of community. The emphasis of the study is on communication processes while CT is the environment and context of the learning groups.

It has been suggested that students' previous experience with CT could affect the team interaction and learning outcomes (Hong, 2002; Shih, et al., 2006). In using CT, studies have also questioned the role of the instructor, who may not be as visible compared to face-to-face classrooms (De Laat, et al., 2007; Lund & Smødal, 2006). Similarly, age and gender could also affect the use of CTs for learning (Hong, 2002; Ramanau & Geng, 2009).

The wiki is the CT of focus in this study. More in-depth research and cleverer measurement methods of wiki effectiveness in collaborative learning environments are needed (Wagner, 2004). Using the survey methodology, the study will investigate the use of two separate wikis (Mediawiki and Confluence) for a team project over a protracted period of one semester. Data from a total of 131 questionnaire responses was analyzed. Findings show strong support for wiki effectiveness, contributing to areas in education, small group research and socio-psychology research, on top of its primary nature in IS. This paper also provides an understanding of the impact of different types of wiki software in education as data was collected from two wikis, one based on Mediawiki software and the other, Confluence software. Theoretical and practical implications from this research will be discussed.

The structure of the paper is as follows: first, the research model and hypotheses will be elaborated on. Next, the research methodology will be described. Data will be analyzed for the two CTs separately followed by an overall discussion. Lastly, the paper will end with implications and concluding remarks.

5.2 Research Model and Hypotheses

5.2.1 Research Model

Informed by the literature discussed earlier, a theoretical model comprising wiki experience, instructor presence, age and gender, the instrumental processes of task-related and socio-emotional activities and finally learning performance and socio-related outcomes is developed.

The input factors are proposed to directly impact task-related activity and socio-emotional activity. These instrumental processes then affect the learning outcomes. The model is depicted in Figure 5.1. All the relationships are in the positive direction. The following sections describe the hypotheses.

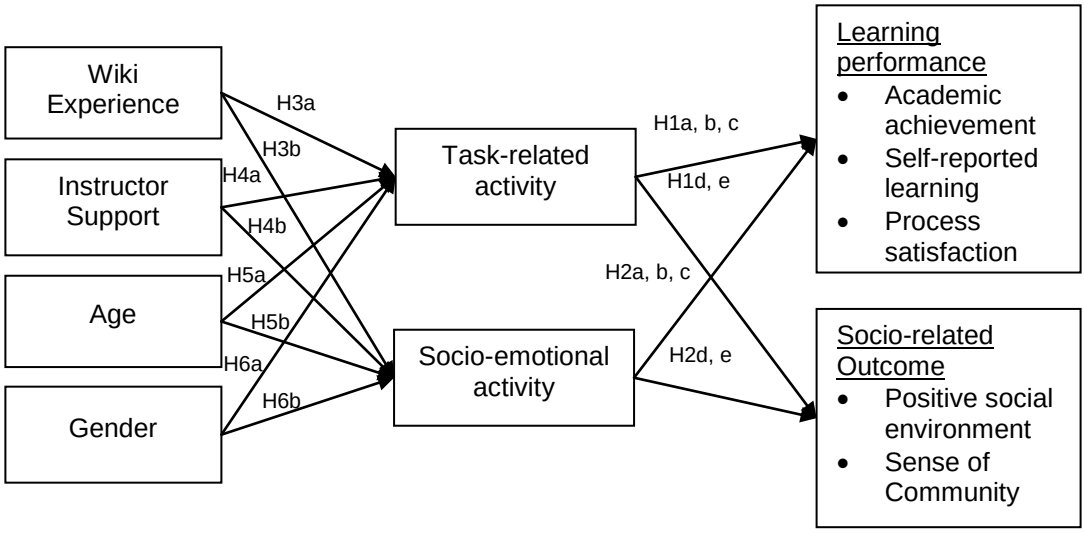


Figure 5.1 Research Model

5.2.2 Task-related Activity

Task-related activity could affect the learning performance and socio-related outcomes of students. Task-related activity refers to behavior that is focused on work. It includes actions such as asking for information and providing information on the task. Higher task-related activity such as information sharing would imply that students are thinking and analyzing the problem which is part of the learning process. When students verbalize and write out their thoughts, they are able to reflect about the task at hand and also generate new ideas. Textual communication between students also allows them to clarify thoughts and develop a frame of thinking. Cress and Kimmerle (2008) explain that wikis allow learners to externalize and internalize knowledge through information exchange. For instance, as learners author a wiki page, they introduce information which reflects their own knowledge. The mental effort required in the contribution of

information can also extend the learner's own knowledge as externalization requires mental processing and clarification (Cress & Kimmerle, 2008). Several studies have reported that students perceived that the wiki facilitated learning of course concepts (Forte & Bruckman, 2007; Minocha & Thomas, 2007). Mindel and Verma (2006) found that the wiki enables collective knowledge in a course and a chronological history of the evolution of the knowledge base. Students perceived the value in using wikis such as encouraging dialogue while writing, which improves the quality of their output.

Rick and Guzdial (2006) report on a field study in an English composition class where one part of the class was randomly selected to use a wiki, and the other, an electronic forum to comment on text readings. Students using the wiki had higher academic grades compared to the forum. In addition, two independent raters found that students using the wiki did significantly better in terms of critical vocabulary and essay organization in their individual essays (Rick & Guzdial, 2006). The research thus suggests that task-related activities on a wiki enable learners to gain higher academic achievement and perceive greater learning.

H1a: Higher task-related activity will be associated with higher academic achievement.

H1b: Higher task-related activity will be associated with higher self-reported learning.

Moreover, increasing task-related activity could also enhance satisfaction (Chou & Min, 2009; Ras, Carbon, Decker, & Rech, 2007). Ras et al. (2007) found that students had positive attitudes toward the wiki as they used it to share information. Students responded that the system saved them effort in experience management, requirements, design, quality assurance and project management in the Computer Science course. However, the study lacked direct measures to assess reflective learning and the evaluation was rather heuristic. Still, the empirical study contained objective (wiki statistics) and subjective measures (through a questionnaire).

H1c: Higher task-related activity will be associated with higher process satisfaction.

In addition, task-related activity as students exchange information for team projects can enhance the social environment and the sense of community (Fuchs-Kittowski & Köhler, 2005). As learners make suggestions and ask for information from their teammates, they put effort into the task, and a positive learning climate is fostered. Students also build a sense of cohesion with their teammates as they share information on a collective task. Chou and Min (2009) found that breadth and depth of information sharing significantly influences the learning climate. This provides support for the following hypotheses on socio-related outcomes:

H1d: Higher task-related activity will be associated with higher positive social environment.

H1e: Higher task-related activity will be associated with an increased sense of community.

5.2.3 Socio-emotional Activity

Socio-emotional activity has been highlighted as important for the development of higher learning outcomes (Barab & Duffy, 2000). Socio-emotional activity refers to behavior that is focused on feelings and the self. It includes expressing affection and personal information. Socio-emotional activity can be positive or negative in nature. Research has reported several studies in which learners were fearful of participating in wikis for reasons such as not wanting other members to edit their work (Minocha & Thomas, 2007; Wheeler, et al., 2008) or unwilling to display incomplete drafts of their articles (Carr, Morrison, Cox, & Deacon, 2007). However, positive socio-emotional activity such as expressing friendliness, positive affection, and encouragement in the wiki enables members to develop trust (Flammia, et al., 2010), and common ground to communicate more effectively, which will affect the learning performance (Chudoba, et al., 2005). Positive reinforcements need to exceed negatives ones in order for a group to be viable and complete its purpose (Bales, 1953). If there is only negative

communication, the group will break down and not complete its task. In this regard, the paper will focus on the positive side of socio-emotional activity which can facilitate learning outcomes.

Socio-emotional activity such as showing solidarity, care and concern for others enables students to work together cohesively in a group, thereby producing better results (Kreijns et al., 2007). Carr et al. (2007) found that encouragement and informal conversation of students on the wiki improved the learning process and student perceptions. Similarly, Benbunan-Fich and Hiltz (2003) found that socio-emotional activity helped to increase learner's motivation, which made them work harder and learn more (Benbunan-Fich & Hiltz, 2003). In an empirical study of face-to-face and computer-mediated teams, Tutty and Klein (2008) found that CMC groups had higher academic grades than face-to-face teams. Incidentally, groups using CMC had more socio-emotional communication than face-to-face groups. The research suggests that socio-emotional activity motivated students' to do well in the task which facilitated their academic performance (Tutty & Klein, 2008). In the same way, the following should apply to wiki-based team collaboration. This suggests the following hypotheses:

H2a: Higher socio-emotional activity will be associated with higher academic achievement.

H2b: Higher socio-emotional activity will be associated with higher self-reported learning.

Socio-emotional activity can also improve learner satisfaction. Flammia et al. (2010) qualitatively examined seven virtual teams which used several technologies including a wiki for a Technical Communication project. The study identified 3 teams with strong socio-emotional activities including providing humor, sharing of personal details, and encouragement. The study found that these teams participated actively, had a strong sense of ownership to the project, and were highly satisfied with the experience. For teams that did not engage in much socio-emotional activity, they regretted the lack of social interaction, and were less satisfied with the experience. This suggests that

H2c: Higher socio-emotional activity will be associated with higher process satisfaction.

Socio-emotional activity also allows members to establish trust and perceive a safe and welcoming team environment (Kreijns et al. 2007). Demonstrating friendship, courtesy, and expressing positive affect will engender feelings of community and a sense of belonging in the team. For instance, research has shown that more socio-emotional communication provides members with better social relationships in the team (Robey, et al., 2000). The resulting hypotheses for socio-related outcomes are:

H2d: Higher socio-emotional activity will be associated with higher positive social environment.

H2e: Higher socio-emotional activity will be associated with an increased sense of community.

5.2.4 Wiki Experience

Previous wiki experience could affect subsequent interaction processes and outcomes. Past literature has suggested that previous computer experience is a differentiating factor with students who use IT tools to learn (Fishman, 1999; Koohang, 2004; Lipponen & Lallimo, 2004; Lou, et al., 2001; Shih, et al., 2006). Students who had more computer experience were more satisfied with their web-based course (Hong, 2002) while students who lacked computer experience experienced more stress and anxiety with IT (Lou et al., 2001).

Other research shows that previous computer experience does affect subsequent computer performance (Yan, 2006). A longitudinal study by Yan (2006) examined four types of previous experiences – computer network experience, statistical program experience, email experience, years of computer use. The study found that students' who had previous experience with using computer network systems performed better initially in the project. The author explains that this due to the transfer of specific skills which were relevant to completing the project. In the same way, previous experience with wiki, which includes students' knowledge of how to navigate the

wiki, how to edit text and discuss etc., would be instrumental in enabling task and socio-emotional activity in the wiki. The following hypotheses are proffered:

H3a: Previous experience of using wikis will predict task-related activity such that more experience will result in higher task-related activity.

H3b: Previous experience of using wikis will predict socio-emotional activity such that more experience will result in more positive socio-emotional activity.

5.2.5 Instructor Support

The responsibility of the instructor is increasingly being studied in online contexts (De Laat et al., 2007; Lund and Smødal, 2006). This is more so in the context of a CT such as a wiki where typically the instructor and the student seem to have equal use of it. Lund and Smødal (2006) investigated the instructor's presence in a wiki. They find that wikis do not provide an online space for the instructor as the instructor has the same amount of user rights as the student such as create, edit, move and rename pages and upload files. They are not administrators who can protect pages, delete pages and ban users. This is unlike learning management systems which grants the teacher more access rights and the ability to create and delete pages. Moreover, the instructor's space on the wiki is virtually the same as the student's space. This makes the role of the instructor more ambiguous.

Nevertheless, there is evidence for the importance of instructor support. Instructor support is beneficial in order to scaffold the learning ability of students so that learners can solve problems or accomplish tasks that would otherwise be out of reach. Garrison et al. (2000) add that although social and task-related interactions are necessary in online environments, they are not sufficient to ensure higher learning outcomes; rather, instructor support is required "to design and integrate the cognitive and social elements of a community of inquiry for educational purposes" (p. 92). Research has also demonstrated the importance of indirect instructor support which could be in

the form of instructional design and structure developed by educators and educational technologists (Elgort, 2007; Kanuka, et al., 2007; Mindel & Verma, 2006).

Cubric (2007) reports that students were unwilling to engage with the wiki possibly because of unfamiliarity with collaborative learning and low interest. Instructors had to stimulate the student's interaction with the wiki. The research concludes that the student's interaction with the wiki and other learners depended on the frequency and quality of the instructor interactions, and also the weight of the assignment (Cubric, 2007). Thus, the paper believes that instructor support is positively related to task-related activity and socio-emotional activity.

H4a: Instructor support will predict task-related activity such that more instructor support will result in higher task-related activity.

H4b: Instructor support will predict socio-emotional activity such that more instructor support will result in more positive socio-emotional activity.

5.2.6 Age

Some studies have reported that age has no impact on interaction processes and outcomes (Hong 2002; Karuppan 2001). Nevertheless, preliminary research has highlighted that the age of learners could affect certain processes and outcomes. For instance, Ramanau and Geng (2009) performed a University-wide survey and found that the age of learners affected wiki use. Students aged 20 to 25 years were more likely to use wikis than students aged 17 to 19 years of age or students aged 26 years of age and older.

As for task-related and socio-emotional activities, research on learning approaches and developmental theories provide some evidence for age-related differences. Past research has shown that older learners tend to adopt a deep approach to learning rather than a surface approach (Gow & Kember, 1990; Richardson, 1994). The deep approach to learning involves the critical

analysis of ideas and associating with known concepts. This suggests elaboration, debate and negotiation, all highly intensive task-related activities. On the other hand, the surface approach to learning is related to the acquiescence of information and memorization of unlinked facts. It implies that information will be exchanged without further examination of the details i.e. lower task-related activities will occur. This suggests that older learners will tend to have higher task-related activity e.g. discussing and sharing information as compared to younger learners.

According to developmental theories, older individuals tend to be more self-motivated, disciplined and also have wider life experiences than younger individuals (Harter 1999). This suggests that older learners may want to steer the project forward by promoting affect and support to the team. The wealthier experiences of older learners may also equip them with the strategies to mange group learning in teams such as showing encouragement to team members. In so doing, socio-related activity will be greater for older learners as compared to younger learners. Past studies have provided evidence that age does affect interaction and learning outcomes i.e. older learners performed better than young learners (Dille & Mezack, 1991; Swan, et al., 2000). The paper suggests that:

H5a: Age will predict task-related activity such that older learners will result in higher task-related activity.

H5b: Age will predict socio-emotional activity such that older learners will result in more positive socio-emotional activity.

5.2.7 Gender

Gender may also affect the interaction process in wikis. Past research has suggested several views for gender differences including the task and relationship orientation (Hahn & Litwin 1995) and gender-role socialization and stereotypes (Kray et al. 2002). The task and relationship orientation postulates that men are task-oriented and value self-sufficiency and status, while women are

relationship-oriented and value their own and others' needs. In other words, males tend to value status more while females value connections more. The gender-role socialization and stereotypes perspective posits that gender roles are learnt from young. Societal norms have deemed the traditional gender role namely that men are aggressive and competitive while females are nurturing and cooperative. Socialization through living in the community reinforces the stereotype.

In CMC, gender difference has been found for communication styles (Lind 1999; Guiller & Durndell 2007). Males tend to come across authoritative and argumentative as compared to females who seem to be more encouraging and nurturing (Thomson 2006). In online discussion groups, Guiller & Durndell (2007) found that males were more task-oriented and focused on sharing information in terms of authoritative language as compared to females. In contrast, females wanted to express support and their feelings and engage in more positive socio-emotional activity than men. Similarly, the research posits that in wiki-based groups, a form of CMC, males would have higher task-related activity as compared to females while females would have higher socio-emotional activity as compared to men.

H6a: Gender will predict task-related activity such that male learners will have higher task-related activity as compared to female learners.

H6b: Gender will predict socio-emotional activity such that female learners will have more positive socio-emotional activity as compared to male learners.

5.3 Research Methodology

5.3.1 Research Context and Project Task

A wiki was introduced in a module that taught societal issues related to information and communication technology (ICT) for a team project. This project required students to co-author a

report on implications of ICT in a particular area or country. Topics included “the use and implications of ICT in China” and “the effect of social networking sites”. The broad topic required students to deliberate and scope their area of interest for further analysis as well as to come up with pertinent observations. The pedagogical goal of this project was for students to gain in-depth knowledge of ICT issues. It was hoped that the students would be able to learn to use wiki systems to collaborate more easily and create their report. This project was carried out twice over two semesters under the same instructor and tutor. The project was a requirement for all students and worth 50 per cent of their course grade. The goal and requirements of the project was the same in both semesters, but the wiki software adopted was different. For both wikis, students used it for about 4 months for their team project. Students formed their own group of 3 to 6 members and each group was allocated an URL to access the shared workspace on the hosted wiki. Students would edit the homepage and subsequently expand the website as they created other pages on the wiki. As this course was not an online course, students could meet team members face-to-face. However, students were required to submit and display their project on the wiki, which ensured that the group would make use of the wiki. In the first semester, the teaching staff provided project instruction and technical help to the students. However, the teaching staff realized that students tended to use the wiki to upload the final report, and did not use the features of the wiki to collaborate online. During the next semester, the staff provided a training session to encourage students to use the wiki to collaborate online in addition to project details and technical help.

5.3.2 Choice of Wiki Software

In the first semester, the wiki software, Mediawiki was utilized. Mediawiki is the software used by Wikipedia, a popular online encyclopedia and its interface is familiar to most students. The instructor selected this software as it was thought that student’s familiarity with Wikipedia’s interface would help increase the usability of the wiki. Mediawiki is also available freely and

open source. A tutor helped to set-up the software in a server. In the second semester, the wiki software, Confluence was used. The reason for the change is that the University recently acquired the Confluence software and made it available for all students and the instructors wanted to try out this new system.

They are slight differences in the features of the wiki software. Mediawiki does not have WYSIWYG editing[3] and students can find learning wiki mark-up language difficult to use. Moreover, comments are written in a free-flow discussion page. Students can also edit individual sections. On the other hand, Confluence is a hosted wiki solution by Atlassian. Confluence has WYSIWYG editing, and its comments are in a threaded form, making it easier to follow discussions. Students can indicate if they want changes to the wiki to be emailed to them, and they could also upload a user profile photo. Screenshots of the two software are shown in Figure 5.2 and Figure 5.3. Feature-by-feature comparison details can be viewed at http://www.wikimatrix.org/compare/Confluence+MediaWiki.

5.3.3 Survey Instrument

The survey methodology was chosen to investigate students' perceptions of wiki effectiveness. The survey method is useful for examining relationships between attitudes and beliefs. Survey items were sourced from past literature. A pre-test was conducted with 5 faculty members for content validity. The sorting resulted in the deletion of ambiguous items. The items comprised of one-item measures for the demographics of age (AGE), gender (GEN) and wiki experience (WEX). Multiple items were utilized for the measures instructor support (ISU), task-related activity (TRA), socio-emotional activity (SEA), self-reported learning (SRL), process satisfaction (PSA), positive social environment (PSE) and sense of community (SCO). Task-related activity

[3]WYSIWYG editing refers to software where "what you see is what you get" i.e. users' typed messages are equivalent to what they see on the screen. Software that does not have WYSIWYG editing requires the entering of mark-up language which is different from what will finally be displayed.

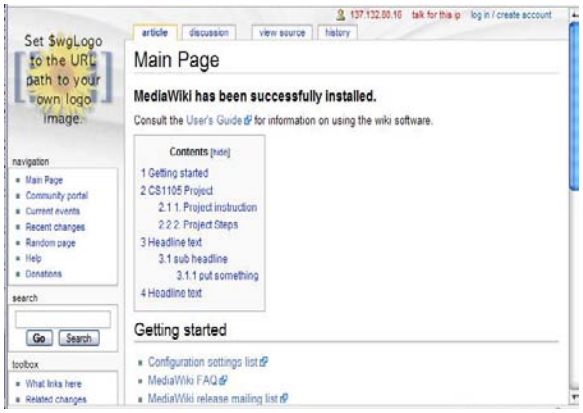


Figure 5.2 Screenshot of Mediawiki

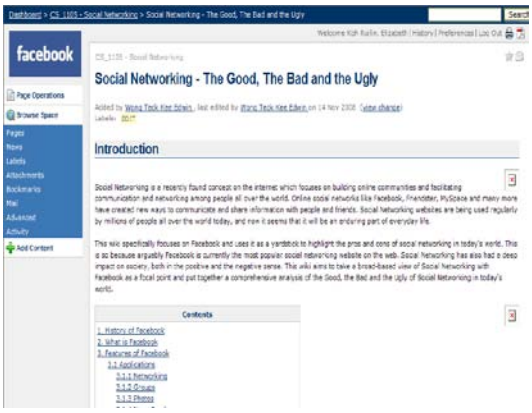


Figure 5.3 Screenshot of Confluence

(TRA) and socio-emotional activity (SEA) were operationalized as perceptions rather than actual content coding as consistent with past literature (Green & Taber, 1980; McGrath, 1991; Walther, Anderson, & Park, 1994). Moreover, self-reports tend to be as accurate as observer coding in such communication activities as they are observable, frequently occurring and desirable (Gosling, John, Craik, & Robins, 1998). All survey items were measured using a scale of 1 to 7 points where 7 is the highest value.

As for academic achievement (ACA), this was measured objectively with the actual grade of the project. ACA was assessed on the criteria topic coverage, correctness, connectivity, language, and student's attainment of in-depth ICT knowledge. The same tutor marked the projects from both wikis. Average ACA was 33.7 for the first semester (std dev 3.60) and 33.6 for the second (std dev 4.81).

5.3.4 Survey Responses

The survey was conducted after students submitted their project. Survey participation was voluntarily and additional participation marks were awarded to students if they participated. There were 63 students in the first course and 45 students responded to the survey which represented all the 15 groups. For the second course, there were 104 students and 86 respondents representing all the 21 groups. The response rate was 71.4% and 82.7% for the two surveys respectively. For both surveys, a verification was done to ensure that at least one member of each

group responded to the survey. Despite the lesser amount of datapoints for certain groups, this did not limit the study as the research analyzed the data at an individual-level; the research aimed at understanding the individual's perceptions of communication processes using the CT. This is consistent with the approach of other studies which examine the individual's perceptions of the group (Hoyle & Crawford, 1994; Jarvenpaa et al., 2004).

Each course consisted of new students; there were no students who repeated the course. The average age of students was 21.71 and 20.43 for the first and second survey respectively. There were 77.8% males (22.2% females) in the first survey and 54.7% (45.3% females) in the second. Age and gender statistics were representative of the course i.e. relatively young students as this was a first-year module and higher number of males which is typical in a computing course. Further break-downs and other demographics are reported in Table 5.1. For instance, WEP for both wikis was low as 33.3% and 55.8% of students respectively for survey 1 and 2 were using it for the first time. The mean results for the items are also shown in Appendix B1.

Partial least squares (PLS) analysis was utilized to test the significant relations among the variables. PLS does not have distributional assumptions of data normality and is able to handle small-to medium-sized samples (Chin, 1998). The following sections analyze the results and discuss the findings from surveys 1 and 2 respectively.

5.4 Survey 1 - Mediawiki

5.4.1 Data Analysis and Results

Tests to the measurement model revealed several cross-loadings which resulted in the refinement of the survey items. The final items of the questionnaire utilized are shown in Appendix B1. These items had adequate internal consistency, convergent and discriminant validity as shown in Table 5.2. Internal consistency, which is commonly measured by the Cronbach's alpha test revealed that all constructs met the criterion of 0.700 (Nunnally, 1978). Convergent validity as

Table 5.1 Demographics of Respondents from both Surveys

Variable	Category	Survey 1 (Mediawiki)		Survey 2 (Confluence)	
		Number	Percentage	Number	Percentage
Computer Experience	Less than 2 years	0	0	0	0
	2-4 years	2	4.4	0	0
	4-6 years	3	6.7	12	14.0
	6-8 years	11	24.4	20	23.3
	More than 8 years	29	64.4	54	62.8
Wiki Experience	Just for this course	15	33.3	48	55.8
	Less than 1 year	10	22.2	9	10.5
	1-2 years	7	15.6	11	12.8
	2-3 years	7	15.6	13	15.1
	More than 3 years	6	13.3	5	5.8
Age	17	0	0	2	2.3
	18	2	4.4	7	8.1
	19	3	6.7	25	29.1
	20	4	8.9	11	12.8
	21	8	17.8	19	22.1
	22	13	28.9	11	12.8
	23	11	24.4	6	7.0
	24	3	6.7	2	2.3
	25	1	2.2	3	3.5

assessed by composite reliability and average variance extracted were higher than 0.500 (Fornell, 1982).

To reduce multicollinearity, the variables were centered (Tamhane & Dunlop, 2000). In addition, the constructs had adequate discriminant validity as shown by the square root of average variance extracted exceeding the correlations between the construct and any other construct.

To rule out the effects of common method bias the common method factor approach was applied (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003). All items were added to a common method factor and run in the PLS model to calculate the variance of the principal constructs and the method (Liang, Saraf, Hu, & Xue, 2007). The research found that the variance of the indicators is 0.712 while the average method-based variance is 0.000001 which represents a ratio of 839796:1. The factor loadings for the method are mostly non-significant. The statistical analysis of the structural model with bootstrapping as well as the model controlled for common method bias is shown in Table 5.4. For the controlled model, some paths increased slightly in strength, whereas

strengths of other paths decreased slightly. However, the pattern of significant relationships did not change. This indicates that the method did not affect the results of the study.

TRA could explain 15% of the variance while SEA explained 7% of the variance from the inputs. Nevertheless there were larger R-squared values for SRL (17%), PSA (21%), PSE (21%) and SCO (12%) except for ACA (6%) indicating that the model has good explanatory power. Eleven hypotheses were significant. However, 2 hypotheses were in the direction opposite to the direction predicted. TRA was negatively related to SCO, path coefficient = -.366, $p<.001$. Males were significantly associated with higher SEA, path coefficient = -0.222, $p=0.052$. Table 5.2 reports the results of the statistical analysis of the structural model with bootstrapping. TRA could explain 13% of the variance while SEA could only explain 5% of the variance from CT experience and instructor support. Nevertheless there were relatively large R-squared values for SRL (51%), PSA (60%), PSE (44%) and SCO (23%) except for ACA (4%) indicating that the model has good explanatory power. Six hypotheses were supported while 2 were close to significance in the proposed direction. These two hypotheses were the effect of ISU on SEA, path coefficient = 0.181, $p=.066$ and the relationship between TRA and ACA, path coefficient = 0.270, $p=.060$.

5.4.2 Discussion

It seems that learning outcomes PSA, PSE and SCO can be explained by TRA and SEA as seen by the relatively high R-squared values. In particular, TRA and SEA combined affect PSA and PSE the most.

As for the effect of TRA on learning performance, this was not evenly supported in the wiki. TRA significantly affected ACA and PSA but not SRL. While the results may seem puzzling at first, the lack of significance for SRL could be due to students sharing information and coming to quick consensus with each other. As mentioned earlier, students did not use the wiki to discuss

information with each other, but rather as a space to upload and deposit what information they had gathered. Students shared this information without going to the extent of expressing personal ideas or identifying the central issue. They did not engage in any task conflict as they were eager to please each other and complete the project smoothly. They could have produced a relatively good project which was well-organized and cohesive which is shown by the significant ACA. However, students' sharing of information did not contribute to their SRL as they went along with sharing superficial information without going in-depth and interrelating the knowledge, or negotiating with other students and conveying their own ideas. In this regard, SRL was lowered and not affected by TRA. Another possible reason for the lack of significance for SRL was that students were already familiar with the topic that had chosen (Ravid, Kalman, & Rafaeli, 2008). As teams could select their preferred ICT topic, students might have chosen topics which they already had a high amount of knowledge in. Thus, they may not have gained new knowledge or skills as they shared information about the topic. Still, their high level of knowledge about their topic led to them receiving high project grades i.e. ACA.

A surprising finding was that TRA was negatively related to SCO. Too much focus on sharing information led to lower feelings of connectedness among the group. Emphasizing on the task only seems to have alienated team members. The later section will discuss this more.

SEA affected learning performance of SRL and PSA except for ACA. A reason for this might be that students who produced more socio-communication naturally felt more positive towards their learning and the process of collaboration. On the other hand students' SEA did not translate into good grades as students were more focused on agreeing with other members and not engaging in relational conflict that could have affected the quality of the report. As for the subsequent relationships of the effect of SEA on socio-related outcomes, these were all significant in the direction predicted.

From the data, WEP did not affect task-related or socio-emotional activity. A possible reason could be the way WEP was measured, it was measured in terms of years of experience rather than students' knowhow of the wiki over the years of using it. Although close to 45% of the students had used Mediawiki for more than a year, they could have used it at a very basic way in popular platforms like Wikipedia and Wikitravel i.e. browsing through the websites for information. Students might not have had any experience in editing and formatting the wiki which would help them to exchange information easily.

ISU significantly affected TRA as predicted. However, this was not significant for SEA. It could be that the instructor during this first semester focused on the task only without encouraging students to socially interact or manage the team dynamics in the wiki. Nevertheless the sign for SEA was in the direction hypothesized. More will be discussed in the overall findings section.

A significant effect was found for AGE and TRA but not for SEA. Older learners had more task-related activity probably as a result of deeper learning strategies used. However, both older and younger learners contributed to SEA, irrespective of their experience. The lack of age differences could be explained by the generation effect where younger students tend to be more comfortable with technology as compared to older learners (Hills & Argyle, 2003). This may predispose them to share personal information and provide encouragement easily on the wiki.

As for GEN, there was no significant effect for GEN and TRA. However, there was a significant effect between GEN and SEA opposite to the prediction i.e. males had higher SEA than females. Some insight into this finding draws from gender research examining the behavior of gender in teams. Research has shown that the gender composition of team members affect how an individual behaves (Savicki & Kelley, 2000). In mixed-gender groups, females have been shown to behave more task-focused and less socio-emotional than

in female-only groups (Flanagin, Tiyaamornwong, O'Connor, & Seibold, 2002). In this course, there were more males than females, and groups were mostly mixed-gender. This reaction of females in groups explains why there were no significant differences in the relationship between gender and TRA. Less SEA expressed by females in mixed-gender groups also explains why there was no significant difference in the relationship between gender and SEA.

5.5 Survey 2 - Confluence

5.5.1 Data Analysis and Results

Similar data analysis tests from Survey 1 were performed for the dataset for Survey 2. Measurement model results reveal general acceptable reliability, convergent validity and discriminant validity (Table 5.3). The variance of the indicators is 0.725 while the average method-based variance is 0.0001 which represents a ratio of 6207:1. The factor loadings for the method are mostly non-significant. The structural model results as well as the model controlled for common method bias are shown in Table 5.5. There was slightly more fluctuation in the controlled model as compared to the structural model. However, the pattern of the paths did not change. This suggests that the method did not have a large influence on the results of the study.

TRA could explain 3% of the variance while SEA could explain 8% of the variance from the inputs. The R-squared values for ACA was 3%, SRL 27%, PSA 16%, PSE 25% and SCO 9%. Nine of the 18 paths were significant. However, one hypothesis was supported in the opposite direction. SEA negatively affected ACA, path coefficient =-.196, p=.029.

5.5.2 Discussion

For learning performance, TRA affected SRL only and not ACA and PSA. In this survey, the non-significant findings for ACA and PSA could be because information overload occurred. Students contributed too much task information which was redundant and overlapping leading to

Table 5.2 Measurement Model Results from the First CT – Mediawiki

	CR	α	AVE	1	2	3	4	5	6	7	8	9	10	11
1. WEP	1.000	1.000	1.000	***1.000***										
2. ISU	0.944	0.925	0.771	*0.105*	***0.878***									
3. AGE	1.000	1.000	1.000	*0.158*	*0.247*	***1.000***								
4. GEN	1.000	1.000	1.000	*0.025*	*0.034*	*-0.106*	***1.000***							
5. TRA	0.874	0.784	0.699	*0.069*	*0.313*	*0.259*	*-0.138*	***0.836***						
6. SEA	0.835	0.698	0.632	*0.128*	*0.102*	*0.032*	*-0.211*	*0.422*	***0.795***					
7. ACA	1.000	1.000	1.000	*-0.034*	*0.007*	*-0.110*	*0.116*	*0.231*	*0.013*	***1.000***				
8. SRL	0.954	0.935	0.837	*0.094*	*-0.103*	*-0.285*	*0.134*	*0.156*	*0.413*	*0.136*	***0.915***			
9. PSA	0.876	0.790	0.703	*-0.210*	*0.140*	*0.137*	*0.180*	*0.388*	*0.391*	*0.272*	*0.224*	***0.838***		
10. PSE	0.942	0.930	0.645	*0.161*	*0.191*	*0.259*	*-0.069*	*0.331*	*0.433*	*0.218*	*0.254*	*0.447*	***0.803***	
11. SCO	0.918	0.868	0.789	*0.211*	*-0.094*	*-0.047*	*0.148*	*-0.253*	*0.114*	*0.116*	*0.290*	*-0.034*	*0.319*	***0.888***

Notes: CR= Composite Reliability. α = Cronbach's Alpha. AVE= average variance extracted. Italics = Correlations between constructs. Bold = square root of AVE.

Table 5.3 Measurement Model Results from the Second CT – Confluence

	CR	α	AVE	1	2	3	4	5	6	7	8	9	10	11
1. WEP	1.000	1.000	1.000	***1.000***										
2. ISU	0.932	0.908	0.734	*0.119*	***0.857***									
3. AGE	1.000	1.000	1.000	*0.198*	*0.142*	***1.000***								
4. GEN	1.000	1.000	1.000	*-0.386*	*0.035*	*0.021*	***1.000***							
5. TRA	0.882	0.805	0.714	*-0.091*	*-0.031*	*0.126*	*0.093*	***0.845***						
6. SEA	0.747	0.686	0.504	*0.051*	*0.283*	*0.061*	*0.016*	*0.478*	***0.710***					
7. ACA	1.000	1.000	1.000	*-0.037*	*-0.163*	*-0.051*	*-0.004*	*0.039*	*-0.132*	***1.000***				
8. SRL	0.946	0.925	0.816	*-0.243*	*0.227*	*-0.111*	*0.019*	*0.463*	*0.424*	*0.024*	***0.903***			
9. PSA	0.955	0.929	0.876	*0.167*	*0.047*	*0.077*	*-0.161*	*0.294*	*0.386*	*-0.201*	*0.215*	***0.936***		
10. PSE	0.948	0.938	0.673	*-0.099*	*0.099*	*0.060*	*0.017*	*0.399*	*0.455*	*-0.129*	*0.516*	*0.481*	***0.820***	
11. SCO	0.949	0.919	0.861	*-0.090*	*0.077*	*-0.007*	*0.053*	*0.180*	*0.292*	*-0.029*	*0.424*	*0.356*	*0.528*	***0.928***

Notes: CR= Composite Reliability. α = Cronbach's Alpha. AVE= average variance extracted. Italics = Correlations between constructs. Bold = square root of AVE.

Table 5.4 Survey 1 Results

Structural relation		Survey 1 Model		Controlling for Common Method Bias	
		Path Coeff	t-Value	Path Coeff	t-Value
H1a	TRA -> ACA	0.274**	3.432	0.270**	3.328
H1b	TRA ->SRL	-0.022	0.121	-0.014	0.089
H1c	TRA -> PSA	0.271**	3.199	0.291**	3.665
H1d	TRA -> PSE	0.181*	2.143	0.168*	2.041
H1e	TRA -> SCO	-0.366***	3.712	-0.362***	4.235
H2a	SEA -> ACA	-0.103	1.173	-0.100	1.258
H2b	SEA -> SRL	0.422***	4.777	0.414***	5.709
H2c	SEA -> PSA	0.277**	3.378	0.248**	3.193
H2d	SEA -> PSE	0.357***	4.072	0.332***	3.648
H2e	SEA -> SCO	0.269*	2.624	0.249**	3.498
H3a	WEP -> TRA	0.016	0.186	0.005	0.059
H3b	WEP -> SEA	0.128	1.326	0.131	1.383
H4a	ISU -> TRA	0.273***	3.558	0.262**	3.297
H4b	ISU -> SEA	0.106	1.289	0.097	1.341
H5a	AGE -> TRA	0.175^	1.795	0.167^	1.857
H5b	AGE -> SEA	-0.038	0.371	-0.036	0.397
H6a	GEN -> TRA	-0.130	1.170	-0.142	1.457
H6b	GEN -> SEA	-0.222^	1.998	-0.220^	1.928

Notes: Path coeff = path coefficient, *** denotes p<.001, **, p<.01. *, p<.05 and ^. p<.1

Table 5.5 Survey 2 Results

Structural relation		Survey 2 Model		Controlling for Common Method Bias	
		Path Coeff	t-Value	Path Coeff	t-Value
H1a	TRA -> ACA	0.133	1.442	0.038	0.466
H1b	TRA ->SRL	0.337***	3.855	0.445***	6.239
H1c	TRA -> PSA	0.142	1.272	0.241*	2.557
H1d	TRA -> PSE	0.235*	2.595	0.283**	3.259
H1e	TRA -> SCO	0.052	0.595	0.107	1.318
H2a	SEA -> ACA	-0.196*	2.218	-0.038	0.404
H2b	SEA -> SRL	0.263**	2.685	0.058	0.679
H2c	SEA -> PSA	0.318**	3.069	0.129	1.224
H2d	SEA -> PSE	0.343**	3.328	0.309**	3.282
H2e	SEA -> SCO	0.268***	3.594	0.159	1.542
H3a	WEP -> TRA	-0.094	1.024	-0.111	1.159
H3b	WEP -> SEA	0.020	0.172	0.085	0.753
H4a	ISU -> TRA	-0.043	0.445	-0.066	0.817
H4b	ISU -> SEA	0.278*	2.478	0.136	1.320
H5a	AGE -> TRA	0.150^	1.913	0.134^	1.625
H5b	AGE -> SEA	0.017	0.219	-0.010	0.129
H6a	GEN -> TRA	0.055	0.555	0.041	0.437
H6b	GEN -> SEA	0.014	0.160	0.070	0.782

Notes: Path coeff = path coefficient, *** denotes p<.001, **, p<.01. *, p<.05 and ^. p<.1

displeasure in the work process. Moreover, this information while helping them to understand the issues and learn, was not organized and integrated well into the project which may have led to the lower ACA.

It was interesting to find that TRA significantly influenced PSE but not SCO. A possible reason is that providing information about the project led to group members feeling that there was a positive team climate and the team could work well together. However, this information exchange was not self-revealing and it was difficult to help group members to get to know each other better.

On the other hand, SEA significantly affected all learning outcomes. However, the relationship between SEA and ACA was significant in the opposite direction. Higher SEA resulted in lower ACA. A possible reason for this is that while SEA encouraged a conducive climate, groupthink could have occurred which prevented teams from seeing other angles and perspectives to their project (Janis, 1972). This was detrimental for their project grades.

WEP did not affect TRA and SEA. Besides the earlier suggested reason, another explanation is the length of time the wiki was used and the time at which the survey was taken. Although 55.8% of the students had never used Confluence before this course, they had used the wiki for almost 4 months in the course and the survey was administered after that. Studies have shown that previous computer experience affects only the initial transfer of information (Yan, 2006). Wiki experience could have given students a head start in their initial team activity but by the later stages, this initial advantage could conceivably have outlived its usefulness.

ISU affected SEA but not TRA. The non-significant finding could be due to instructions provided by the instructor during the second semester. As aforementioned, the instructor organized a training session for the students that emphasized on wiki editing tips and possible collaboration styles on the wiki. For instance, students were informed that when deleting their team member's work, they should indicate why they deleted it. This could have resulted in students expressing politeness and courtesy on the wiki, which are forms of SEA. As for the lack of significance for TRA, it could be because the instructor did not provide other instructions about the task after the training sessions. Students were expected to complete the task by themselves.

The findings for AGE and GEN were similar to Survey 1. The research believes the reasons offered in the earlier discussion apply to Survey 2 too.

5.6 Overall Discussion

The findings of the two surveys reveal certain similar patterns and also some differences. The research performed a post-hoc analysis where the data was combined and the study considered as an independent variable. The post-hoc analysis found that there was no significant difference between any of the variables in the two studies. However, as the separate data analysis has shown, certain differences exist and this section attempts to integrate the results from the 2 surveys.

5.6.1 Interaction Process and Outcomes

In both surveys, TRA and SEA affected learning outcomes. In fact, the influence of SEA on learning outcomes is more significant as compared to TRA. For both surveys, SEA positively influenced 4 out of 5 learning outcomes. However, TRA did not consistently influence learning outcomes. TRA was significant for PSE in both surveys only. This finding demonstrates the saliency of the effect of SEA on learning outcomes which has been traditionally ignored in research (Liu, 2002).

TRA did not equally affect learning performance or socio-related outcomes in both surveys. TRA affected ACA and PSA in Survey 1 but not SRL. In contrast TRA affected SRL but not ACA and PSA in Survey 2. This suggests a learning/satisfaction trade-off in line with previous research (Turoff & Hiltz, 1982). Turoff and Hiltz (1982) highlight a possible compromise between team performance and satisfaction which can be mutually exclusive goals and hard to achieve simultaneously. Focusing on task-oriented activity may lead students to feel satisfied with the smooth process and produce a good project but not interrelating knowledge from the information shared. Alternatively, higher TRA might result in students who have gained knowledge and skills from the information exchanged but unsatisfied with their overload of information during the process which hampered the final

project outcome. The different wikis utilized in the semesters could have played a part too. As mentioned, discussions in Mediawiki were more free-form and there was no specific style of discussion enforced by the software. In contrast, Confluence had a threaded discussion board at the bottom of each wiki page. This could have led students using Mediawiki to focus on contributing and editing content in the report without much discussion, resulting in a good quality report and satisfaction at the ease of collaboration. On the other hand, students using Confluence could have spent more time using the threaded discussion board to discuss and share their thoughts. This may have made it difficult for them to translate their discussion into the report on the wiki, resulting in less PSA and ACA.

TRA did not affect SCO according to the hypothesis in both surveys. This suggests that task-related information sharing is not enough to help students to connect with each other. Survey 1 reveals that TRA led to less SCO suggesting that too much focus on the TRA prevents team members from developing common ground and instead caused them to feel more distant from each other. This is consistent with research that has found CMC harder to build social relations (Dubé & Robey, 2008; Liu, 2002); deliberate effort has to be taken i.e. increasing SEA, to increase SCO.

On the other hand, SEA affected both learning performance and socio-related outcomes rather similarly. The influence of SEA was consistent in both surveys. Results from both surveys showed SEA significantly influencing SRL, PSA, PSE and SCO. However, SEA did not have such a positive impact on ACA. While there was no effect of SEA on ACA in Survey 1, this was significant in the negative direction in Survey 2. In the earlier discussion, reasons such as students' oriented towards group agreement and group think were suggested. Group think has led to several unfavorable performances in group decision-making (Janis, 1972). Another reason could be that SEA was measured to be positive in nature and did not take into account conflicts in the team. Research has shown that some degree of conflict is necessary for quality

work to be produced. Through the argumentation and negotiation of ideas, better solutions are derived (Vygotsky, 1978).

5.6.2 Inputs

As for WEP, both surveys showed no relationship between experience and TRA and SEA. It seems that for both types of wiki software, experience does not matter in influencing the level of activity. Students with less WEP are able to interact equally as well as students with more WEP after some time of usage. Usage familiarity can be built up relatively quickly such as in the 4 months that students' used the wiki in this study.

The results of the role of the instructor were rather different in the two surveys. This can be attributed to the slightly different ways the instructor conducted the course in the two semesters and also how the wiki was set-up. In the first semester, the instructor focused only on providing instructions on the task and technical help with using the wiki. This could have led students to produce more task-oriented information and little SEA. In the second semester, in addition to project details and technical help, the instructor emphasized on collaboration tips and ways to manage group dynamics. This could have led students to produce more SEA rather than TRA. Another possible explanation was the way the wiki was set-up. Mediawiki was set-up by a tutor specifically for the course. Students (including other students not in the same team) and staff in the course could view the various reports on the wiki. Students could have concentrated on producing the best report as they knew other teams could read their report, leading to greater information exchange about the task. On the other hand, Confluence was set-up by the University and all university students had access to it. However, Confluence allowed teams to set-up their page with a private level of visibility. Other students could not view their work, which provided students with more privacy. This could have resulted in more open sharing of feelings and intimate details i.e. higher SEA.

The results for AGE were similar across both surveys. Age affected TRA but not SEA. Older learners produced higher TRA probably as a result of their deep learning strategy which

necessities more discussion and negotiation. On the other hand, learners from all ages were able to generate similar levels of SEA. A possible reason is that while older learners had the experience and maturity for group maintenance behaviors, younger learners were more comfortable with expressing SEA in the online medium. This resulted in similar levels of SEA for learners of different ages.

As for GEN, the results of both surveys suggest that gender interaction processes are more complex than initially hypothesized. Although gender stereotypes exist, individuals adjust to the gender composition of the team they are in, and interact in ways that differ from their gender stereotype (Savicki & Kelley, 2000). As previously discussed, females in mixed-gender teams tend to act more task-oriented and less socio-emotional-oriented, almost akin to traditional male behavior. Some research has explained that this is a coping mechanism adopted by females due to the perception of having lower status or the weaker sex (Flanagin, et al., 2002). This could account for the unsupported hypotheses for the relationship between gender and TRA and SEA.

5.7 Implications and Limitations

The results of the study provide practical and theoretical implications. The research first examines the two different wiki software. Both surveys reveal that the learning outcomes from the two wikis were more similar than different. The one exception was that TRA in Mediawiki led to higher ACA and PSA but not SRL; this finding was reverse in Confluence. As earlier explained this could be because of the threaded discussion forum feature in Confluence which was not available in Mediawiki, and Mediawiki's focus on displaying the content of the report. This implies that wikis may not contain all the features necessary to facilitate all learning outcomes. Further improvement with wiki software to support collaborative learning is necessary. To help in further research and practice on wiki effectiveness, the paper has developed a classification system of wikis based on the current findings, extant literature and observations of the wiki marketplace.

Mediawiki and Confluence are different wiki software. Yet when the two software was used for the same project, the empirical results were strikingly similar. The data revealed similar learning outcomes from positive SEA in both wikis. Indeed, the essence of these two wiki software is that they are browser-based workspaces that allow collaborators to edit and track changes. This suggests that both Mediawiki and Confluence can be seen as similar systems. They are also similar to other wikis in the marketplace with these basic sets of features such as PBWorks and TikiWiki.

The classification of systems is also based on the framework of three levels of systems for group decision support systems (GDSSs) developed by DeSanctis and Gallupe (1987). This research first proposed that Level 1 GDSSs provide basic communication between members while Level 2 GDSSs are enhanced from Level 1 to provide modeling techniques to reduce the uncertainty in decisions. Level 3 GDSSs are the most sophisticated and make use of automated rules and artificial intelligence (DeSanctis & Gallupe, 1987).

Adapting the conceptual framework of system levels, the paper develops a framework for wiki group work consisting of 3 levels of systems. Level 1 wiki systems are wiki software that encompasses the basic features of wikis. These basic features include the shared editing functions, tracking functions and page permissions present in any wiki. Moreover, these features are also asynchronous in nature; they facilitate information exchange of users at their own time and place.

Level 2 systems are wiki software that is substantially enhanced. The enhancements can include features such as group chats to allow more spontaneous communication between members or drawing boards for users to sketch. Level 3 systems are wiki software that is integrated with other organizational wide systems providing a suite of applications where data from one application can be easily transported to another application.

These 3 levels of systems are currently being seen in the IT marketplace. The basic Confluence wiki is a Level 1 wiki system with the central features of a wiki. This was the system level examined in the current study. However, Confluence has macros and plug-ins to enhance it to a Level 2 wiki. Examples of such plug-ins include a Google calendar embed, Gliffy plug-in to create flowcharts, and a MeetingRoom macro for group chats. Level 3 wiki systems are also possible with Confluence which allows full integration with Microsoft SharePoint, Salesforce.com, and IBM's Lotus Connections etc. Table 5.6 illustrates the 3 levels of systems for wiki group work.

Table 5.6 Three Levels of Systems for Wiki Group Work

Collaborative Technology	Definition	Wiki Examples
Level One	The essential features of the system including shared editing, tracking functions and page permissions.	Basic versions of Mediawiki, Confluence, Wetpaint, PmWiki, Google Sites etc.
Level Two	Systems that are substantially enhanced typically by plugins or macros. These enhancements augment the basic features. For example, group chats and drawing boards.	Mediawiki: Rating and review extension, GoogleMaps extension, and Guestbook extensions etc. Confluence: Google calendar embed, Gliffy plugin for flowcharts, and MeetingRoom macro for group chats etc.
Level Three	Systems that are integrated with other organizational wide systems providing a suite of applications where data from one application can be easily transported to another application.	Confluence: integration with Microsoft SharePoint, Salesforce.com, and IBM's Lotus Connections etc. Google Sites: integration with the rest of Google Apps such as Gmail, Google Groups, and Google Docs.

For system designers of wikis, the conceptual framework illustrating the three levels of systems serves as a way of classifying the features of the wiki. Wikis can be enhanced with features that provide ease of collaboration and collaborative learning. From this study, it seems that allowing more avenues for students to communicate on Mediawiki could enhance the SRL of students. Future developers could implement the Mediawiki with a threaded discussion forum or even a group chat, which can be implemented through installing a plug-in. On the other hand, it seems that more focus on the content is required in Confluence, and the developers could develop other enhancements to help transfer discussions from the discussion space to the content space. All these added features in the wiki system would enhance the wiki such that it would be classified as a level two system.

This is also a way for developers of existing level one systems to expand their offerings such that levels two and three wiki systems can be catered for. This could in turn affect their wiki adoption rates and reputation. For instance, for Mediawiki, there is currently no level three system which provides integration to application suites. Mediawiki developers can provide integration to other open source organizational suites such as OpenOffice which can potentially lead to greater interaction and outcomes for group members.

Moreover, the current study has shown that SEA affect outcomes. While not ignoring the instrumental needs in team projects, designers should also cater for SEA by developing functions that will maintain the positive activity of the team. For instance, a positivity level indicator plug-in could be added to wiki systems.

This framework also serves as a guide for educators in selecting wiki software. As a baseline, level one systems provide the basic features for collaboration and outcomes. As shown in the study, using wikis for team projects does affect learning performance and socio-related outcomes. However, not all learning outcomes seem to be catered for in every wiki software. Educators may need to choose a level 2 wiki system which can possibly enhance more learning outcomes.

Another practical takeaway for educators is with regard to the inputs, WEP, ISU, and age. The study's findings suggest that WEP should not be too much of an issue for educators in deciding to adopt a wiki for collaborative learning. WEP did not affect interaction processes or learning outcomes. Rather, educators should select a wiki software that fits their personal and/or organizational goals. As for ISU, this is crucial in enhancing TRA and SEA. Educators should provide equal emphasis on instruction with regard to the project at hand as well as the group maintenance functions. This will encourage students to contribute both TRA and SEA. Lastly, the findings suggest that younger learners may not be able to share as much TRA as compared to older learners. Educators should encourage these younger learners to be critical

of information collated and discuss them in greater detail rather than gloss over them superficially.

Next, the paper suggests areas for future research. First, the paper has examined level one wiki systems and shown how they have affected learning outcomes. Further research could investigate level two and level three systems to verify their effectiveness. A possible future study can compare between level one and level two wiki systems and determine the extent of effectiveness for team projects.

Second, gender composition in team projects using wikis could be further examined. The findings from this study indicate that the gender composition in teams affected the interaction behavior and outcomes. Team composition in future studies could be specifically manipulated such as forming mixed-gender, all female and all male teams and its impact investigated.

Third, the study highlights the pitfall of only focusing on TRA. Further studies should continue to examine SEA in addition to TRA. This will extend the line of study by Bales (1950) for a relatively new type of IT, the wiki. One particular area could be the degree to which the two activities are needed for learning outcomes i.e. the balance of the two communication activities. Another area is to examine the temporal nature of the two activities, where a particular activity could be crucial at a certain phase or stage in a group's lifespan.

Fourth, to further evaluate the effectiveness of wikis, other studies should compare between traditional face-to-face teams and teams using wikis. This can provide further evidence of the effectiveness of wikis.

The study suffers from several limitations. The research did not design a comparison between two wiki software, or wiki software and other types of collaboration software or with face-to-face collaboration. This limits the extent to which the claim of wiki effectiveness can be

drawn. Based on the study, the research provides evidence that using wikis for team projects enhance learning outcomes for learners.

Another limitation is that the researchers were unable to guarantee that all the features of the wiki were utilized. For instance students might not have uploaded a photo or used the discussion pages in the wiki. Nevertheless, as the paper conceptualized, these two wikis can be considered to be at the same level i.e. level 1 wiki systems, which contain basic wiki features. Based on similar findings from both surveys, the paper suggests that these two wikis are roughly equivalent.

Next, the paper uses the survey methodology which limits the identification of causation. The survey also had small sample sizes and not all students who used the wiki participated in the survey. Nevertheless, the cause-effect linkages were theoretically sound and the survey was replicated twice resulting in similar findings, suggesting the soundness of the model.

In addition, the results from this study may not be able to generalize to other contexts due to the uniqueness of the team, task etc. Collaborative learning and virtual team constructs were also not examined. Going further, the research agenda will be to examine other factors such as wiki system levels to develop a more comprehensive study of wiki effectiveness.

5.8 Concluding Remarks

This paper addresses a missing gap in literature by examining the interacting processes of learning groups using wikis. The study has found that wikis can affect learning outcomes of ACA, SRL, PSA, PSE and SCO through the processes of TRA and SEA. Four input factors were also investigated. Although WEP did not affect interaction activity, ISU was able to influence both activities. AGE also affected TRA but not SEA while the effect of GEN highlights the importance of group composition.

Among its contributions, this paper is one of the few empirical studies that rigorously examine the use of wikis and learning outcomes. Moreover, the relationship is robust enough to be observed in two separate wikis which possessed different features.

The research has also delineated the importance of examining both instrumental and expressive needs of teams. Previous studies have tended to focus on task-oriented activity, suggesting that collaboration systems only cater for that. However, this paper has shown that TRA and SEA both affect learning outcomes. Moreover, the data shows stronger support for the relationship between positive SEA and learning outcomes as compared to TRA. This highlights the importance of examining SEA in group work. Furthermore, the study has provided practical and theoretical suggestions for educators, system developers and researchers. This includes a framework of wiki system levels that provides direction for future research and practice.

In sum, the paper has contributed a greater insight of wiki effectiveness together with a rigorous empirical study conducted using two wikis. It has illuminated the black-box of input-output models by examining both task and social aspects of team interaction activity and the impact of WEP, INS, AGE and GEN on TRA and SEA. Moreover, the data strongly supports that interaction processes affect learning outcomes. In particular, positive SEA enhances SRL, PSA, PSE and SCO.

Wikis are being rampantly used in many industries. This is no different in education. This paper provides a theoretical lens for the effectiveness of wikis for student team projects. Tested using two separate wikis (Mediawiki and Confluence) over a protracted period of one semester, findings show consistent and strong support for wiki effectiveness. Indeed, this line of research coupled with popular support for the wiki points to a bright future for wiki use and evolution.

Chapter 6: Study III - The Interplay of Collaborative Technology with Learner Characteristics: Interactional Examinations

6.1 Introduction

The world today has shrunk into a global village, save some countries. With CT, people from all over the world can share a single platform to collaborate on distributed teams. Yet despite the convenience that CT provides, members of distributed teams frequently encounter more conflicts (Mortensen & Hinds, 2001), miscommunication (Ocker & Fjermestad, 2008), and lower morale (Warkentin, Sayeed, & Hightower, 1997) as compared to collocated teams. At the same time, developments in the computing world have seen a mounting trend of sophistication with many CTs becoming browser-based. With the influx of Web 2.0 concepts such as increased participation and social networks, CTs have increasingly accommodated more sociable characteristics, which are defined in the paper as sociability. A CT characteristics, sociability is the degree to which CT facilitates the emergence of a sound social space in which healthy social relationships among team members are formed, as seen in group norms, roles, and beliefs (Kreijns, et al., 2002).

CTs can be used for work groups and learning teams. In education, CTs have been used formally by online and blended educational programs e.g. CoWeb at the Georgia Institute of Technology and informally by students e.g. openstudy.com. The rise of blended learning courses in which collocated students utilize CT for learning suggests the increasing importance of examining distribution and proximity in learning (Diaz & Brown, 2010; U.S. Department of Education, 2010). Indeed, the proximity of the learner is a learner characteristic that requires further investigation. Brandon and Hollingshead (1999) surmise that collaboration, communication, and social context are crucial components in computer-supported collaborative learning (CSCL). However, past research has not shown how the current social context of collaborative learning, notably the use of wikis, has affected learning outcomes. Specifically, this study is interested in examining the sociable aspect of CTs together with the effects of proximity, in affecting learning outcomes. The first research

question is, “how does the interplay of CT sociability and proximity affect learning outcomes?”

A stream of research has highlighted the task-social communication dichotomy in both face-to-face groups and computer-mediated ones (Bales, 1950; Bion, 1961; Fjermestad, 2004). In seminal research, Bales (1950) found that groups continually divide their time between instrumental (task-related) and expressive (socio-emotional) needs. Task-related activity refers to content about the project at hand while socio-emotional content refers to personal details, feelings and encouragement. In addition, the research theorized an equilibrium model in which groups seek to maintain a balance of instrumental and expressive acts through progressive stages. Successful group outcomes then depend on how groups are able to solve the task and maintain member satisfaction. Similarly, other studies have proposed that a balance of task-related activity and socio-emotional activity is needed for group effectiveness (Barron, 2003; de Vries, et al., 2002; McGrath, 1991).

This study thus conceptualizes that a balance of task-related activity and socio-emotional activity is required for learning outcomes. This is coined the task-related and socio-emotional activity balance (TSAB) which represents the equilibrium effect in the team where there are equal amounts of perceived task-related and socio-emotional communication. This extends the research on the role of task-related and socio-emotional activities. The earlier study, Study II, examined the direct effect of task-related activity and socio-emotional activity on learning outcomes in wiki project teams. In this study, the research examines the importance of task and socio-emotional activities through investigating TSAB. The second research question is, “what is the effect of TSAB on learning outcomes?”

As highlighted in this thesis, the development of learning outcomes does not occur independently from the social context, also known as inputs. Rather, inputs and processes inherently influence learning outcomes. Outcomes can be affected by the interacting relationships between the inputs CT sociability and proximity, and TSAB (Terborg, 1981).

The final research question is, “how is the relationship between the social context and learning outcomes affected by TSAB?”

To examine the research questions, a field experiment in the education context was conducted. A total of 159 students used two different CTs in a project that spanned Singapore and the United Kingdom. The contributions of this research are threefold. First, it suggests that CT sociability is important for the learning environment which will guide development for future CTs. Second, the salience of proximity is shown despite growing occurrences of distribution in globally virtual teams. The research contributes to this area by pinpointing how distribution can be improved by using CT sociability and task-related and socio-emotional communication. Third, it demonstrates the importance of TSAB in time-limited computer-supported learning teams.

This study begins with the research model and hypotheses. Next, the research methodology is discussed followed by the data analysis and results. A discussion of the findings is then deliberated on. In the penultimate section, the paper describes the implications and limitations of the research before identifying study’s contributions in the conclusion.

6.2 Research Model and Hypotheses

6.2.1 Research Model

This study will examine learning outcomes in terms of self-reported learning, academic achievement and positive social environment. Self-reported learning focuses on the perceived knowledge and skills acquired (Alavi, 1994). Academic achievement refers to the cognitive gain of learners and is an objective measure which is typically the academic grades of the student (Bloom, 1956). Positive social environment, also known as the learning climate, measures the overall social climate of the team in terms of work relationships, trust, respect and belonging (Kreijns, et al., 2007). These learning outcomes have been commonly used in the past (Alavi, 1994; Bloom, 1956; Kreijns, et al., 2007).

Three components are critical in CSCL - collaboration, communication, and social context (Brandon & Hollingshead, 1999). The inputs of this study, also known as the social context, are CT sociability and proximity. These two constructs pertain to the technology dimension and learner dimension respectively. These affect learning outcomes directly and also interact to affect learning outcomes. In addition to the social context, learning outcomes are generated by the collaborative development of shared meaning which requires a substantial amount of communication activities. The paper concentrates on the communication process in terms of a balance of task-related and socio-emotional activity (Bales, 1950). TSAB is proposed to directly affect learning outcomes as well as to interact with the inputs CT sociability and proximity in affecting learning outcomes.

The research model is illustrated in Figure 6.1. The hypotheses are developed in the subsequent sections.

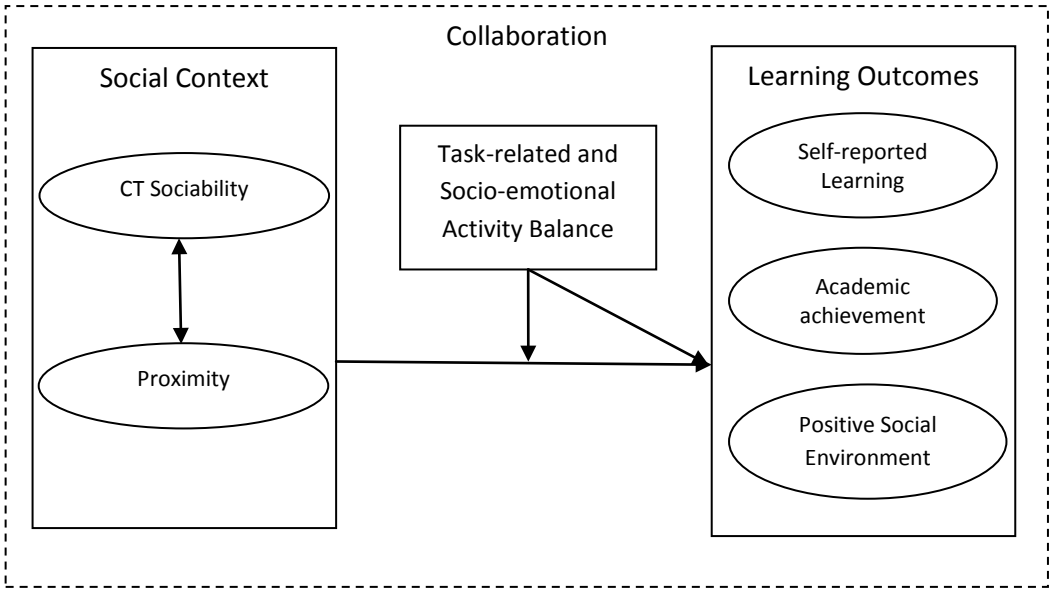


Figure 6.1 Research Model

6.2.2 Sociability

Computing developments of the twenty-first century has resulted in CT with high sociability. CTs are being designed to encompass many modules of interactivity. Basically, there is not just one asynchronously shared workspace; rather there are multiple avenues for individuals

to interact. For instance, Google Docs, an online authoring workspace, has added a chat feature while WetPaint, a hosted wiki, allows users to embed polls and chats.

High CT sociability would encourage more communication (Boyd, 2007), knowledge sharing and seeking (Phang, 2009), dialogic argumentation (Clark, et al., 2007) and afford more spontaneous information sharing among team members compared to low CT sociability (Kreijns, et al., 2002). This higher interactivity among learners where knowledge is shared and discussed leads to higher learning outcomes as posited in collaborative learning theory (Vygotsky, 1978). Benbunan-Fich and Hiltz (2003) found that perceived collaboration among students in online courses led to higher self-reported learning. Similarly, LaPointe and Gunawardena (2004) found that peer interaction enhanced self-reported learning. In the same vein, with the use of high CT sociability which allows more interactive and passive means of communicating and collaborating, self-reported learning will increase.

Research on small group learning in face-to-face groups has shown that higher learner-learner interaction would provide for more discussion and better content hence enhancing academic achievement (Niebuhr & Niebuhr, 1999). Similarly, online learners produced higher final academic grades when they frequently participated and spent longer time using CT (Morris, Finnegan, & Wu, 2005). The research explains that these students were more motivated to complete the course and therefore participated more intensely. In a virtual team study conducted between courses in the United States and Hong Kong, researchers found that higher communication among team members improved academic performance (Fuller, Hardin, & Davison, 2006). Communication level was seen as an objective measure for effort; students spent more energy on the project which led to higher grades. High CT sociability, which allows learners to interact more easily, should enhance communication efforts by learners, and lead to better academic grades.

Furthermore, media richness theory suggests that high CT sociability can lead to higher academic achievement. High CT sociability which is a richer media than low CT sociability

will be more suitable for the transmission of equivocal messages. The wider bandwidth in high CT sociability will support the accurate transmission of meaningful ideas, allow quick information exchanges and ease of access for the users. In sum, this will allow learners to contribute information easily and clearly and produce a better deliverable.

Positive social environment should also be affected by CT sociability. Arbaugh and Benbunan-Fich (2007) explain that learners derive social and community support from their interaction using the CT. High CT sociability enhances social presence which leads to a healthy learning climate (Kreijns, et al., 2007). Similarly, high CT sociability encourages informal conversation and more learner-learner interaction which helps learners overcome feelings of remoteness (Eom, et al., 2006). High CT sociability will also encourage breadth and depth of information sharing which affects satisfaction and the learning climate (Chou & Min, 2009). Research has shown that higher communication frequency (Dawson, 2006) and more effective communication (Lin, Standing, & Liu, 2008) led to higher cohesion and a sense of community. The literature thus suggests a positive relationship between CT sociability and positive social environment.

The above deliberation leads us to propose three hypotheses:

H1a: CT Sociability is positively associated with self-reported learning.

H1b: CT Sociability is positively associated with academic achievement.

H1c: CT Sociability is positively associated with positive social environment.

6.2.3 Proximity

Past research has traditionally compared distributed learning using CT with face-to-face instruction. A majority of research has shown that distance learning using CT can be as effective as traditional face-to-face instruction (Bernard, et al., 2004; Hiltz, et al., 2000; Johnson, et al., 2002). Nevertheless, the use of blended learning in which collocated students

learn from a mixture of online and face-to-face approaches is on the rise (Diaz & Brown, 2010; U.S. Department of Education, 2010). However, research has hardly compared the use of CT in collocated and distributed environments. This paper fills the missing gap by examining the effect of proximity in learning teams using CT. Proximity in this study refers to the nearness of team members and teams can be differentiated into collocated i.e. all members located in the same area, and distributed i.e. members are dispersed across different areas. Teams that are collocated are spatially, temporally and culturally close while distributed teams are of the reverse (Chudoba, et al., 2005; O'Leary & Cummings, 2007; Ocker, et al., 2009).

When all things are held constant i.e. the use of the same CT and learning activity, evidence suggests that proximity will affect learning outcomes especially in project teams (Cramton, 2001; Curtis & Lawson, 2001). In learning groups that are completing a time-finite project, members need to communicate, coordinate and contribute to the task. However, distribution can affect the learning outcomes of members due to spatial, temporal, and cultural separation.

Self-reported learning will be affected by proximity. Proximity will allow team members to share information easily (Cramton, 2001; Hinds & McGrath, 2006) and understand each other better (Zenger & Lawrence, 1989) which will foster greater peer learning. From collaborative learning theory, greater negotiation and shared mental models among learners helps in fostering greater learning (Vygotsky, 1978). Moreover, collocated teams will experience less task and interpersonal conflict than distributed teams. Although some degree of task conflict is associated with higher perceived learning (Johnson & Johnson, 2009), too much task conflict dampens learning (De Dreu & Weingart, 2003; Jehn, 1995; van Woerkom & van Engen, 2009). Sarker (2005) reports that cultural differences reduced the perceived knowledge transfer in collaborating teams from the U.S. and Thailand. Collocated team members who are able to share information easily and experience less conflict (Hinds &

Mortensen, 2005) will therefore have higher self-reported learning than distributed team members.

Proximity may also allow teams to reduce coordination delays and make faster decisions (Burke, Aytes, Chidambaram, & Johnson, 1999; Chudoba, et al., 2005; Cummings, et al., 2009). This is more so for time-limited groups with deadlines (Walther, 2002). On the other hand in distributed teams, Cramton (2001) found that a lack of contextual information, unevenly distributed information and differences in the salience of information resulted in poor information exchange and lowered academic grades. Communication and language difficulties and different educational expectations among learners of different cultures also lowered academic achievement (Economides, 2008). O'Leary and Cummings (2007) advocate that increasing site configurations, which is the case of distributed teams, increase coordination complexities. In sum, the literature suggests that collocated learners using CT might have higher academic achievement compared to distributed learners due to more mutual knowledge, clearer information flow and ease of coordination.

As for positive social environment, some research has suggested that distributed teams can develop a healthy social climate (Jarvenpaa & Leidner, 1999; Johnson, et al., 2002). For instance, distributed teams developed swift trust while working on short-term projects (Jarvenpaa & Leidner, 1999). However, this study did not compare between collocated and distributed groups. Other research that has compared collocated and distributed teams has shown that groups developed similar levels of cohesion in a short-duration task (Chidambaram & Tung, 2005). The research, however, operationalized distributed teams as only spatially distant, as participants used CT from different rooms in the same building.

Spatial, temporal and cultural proximity will affect the social climate of the group (Cramton, et al., 2007; Peña, Walther, & Hancock, 2007). The similarity-attraction theory (Bryne, 1971) explains that individuals will tend to have increased liking for other individuals from a similar location and background. In learning groups, this attraction will facilitate cordial relations and

enable a positive social climate. Pena et al. (2007) found that collocated group members as compared to distributed group members, who were geographically dispersed across six Universities in North America, had more symmetrical perceptions which resulted in higher cohesion in the group. Misattribution is also higher in distributed teams as compared to collocated teams (Cramton, et al., 2007). This lowers the positive social climate of the group as when members do not share situational information for instance, certain time differences, they are seen in a negatively light such as being lazy or rude. Moreover, cultural tensions were seen in a case study of collaborating teams between the U.S. and South Africa (Cogburn & Levinson, 2003). Team members described that cultural differences in communication styles hindered the building of a positive learning community.

Based on the above deliberation, the study proposes the following:

H2a: Collocated team members, as compared to distributed team members, will have higher self-reported learning.

H2b: Collocated team members, as compared to distributed team members, will have higher academic achievement.

H2c: Collocated team members, as compared to distributed team members, will have higher positive social environment.

6.2.4 Interaction between CT Sociability and Proximity

There may also be a relationship between CT sociability, proximity and learning outcomes. In distributed teams, CT sociability by allowing more avenues for formal and spontaneous communication can increase information sharing among distributed team members. This reduces difficulties in distributed communication and coordination e.g., allows them to gain shared understandings, reduces conflicts, and ultimately results in better learning outcomes (Espinosa, Cummings, Wilson, & Pearce, 2003; Hinds & Mortensen, 2005; Sarker, 2005; Suh & Shin, 2010). On the other hand, collocated team members already identify with each other,

have shared mental models, communicate well and have low levels of conflict (Economides, 2008; Peña, et al., 2007). More communication provided via CT sociability may not have such a strong effect on group outcomes on collocated teams. In other words, the use of high CT sociability on learning outcomes may be stronger on distributed teams as compared to collocated teams.

Suh and Shin (2010) found that frequency of online interaction affected knowledge sharing in distributed teams but not in collocated teams. In a study of distributed teams, Sarker (2005) found that the amount of communication positively affected the knowledge gain of students. The literature thus suggests that higher interaction afforded by CT sociability improves group communication in distributed teams more than collocated teams, resulting in higher self-reported learning for distributed team members.

In the team literature, although distributed teams as compared to collocated teams have been associated with lower performance, the effects are mitigated by increasing communication and shared knowledge (Espinosa, Slaughter, Kraut, & Herbsleb, 2007; Hinds & Mortensen, 2005). Chudoba et al. (2005) even found that team distribution did not affect team performance, rather adequacy of team social interaction predicted performance. Hinds and Mortensen (2005) surveyed 21 collocated and 22 distributed work teams and found that distributed teams had higher task conflict which resulted in lower perceived performance. However, spontaneous communication moderated the relationship between distribution and conflict. Based on a case study of a large software team, Espinosa et al. (2007) proposed that shared knowledge, team awareness, and presence awareness compensates for the negative effects of distribution. In the same manner, we suggest that CT sociability by enabling more spontaneous interaction and shared understanding among learners in distributed teams will enable better academic performance.

Lastly, the relationship between proximity and positive social environment could be affected by CT sociability. CT sociability by increasing avenues of interaction might enable greater

shared understandings and offset physical, temporal and cultural differences of distributed teams. Increasing member-member interaction would engender feelings of closeness between distributed teammates. In that regard, CT sociability could help reduce the differences in distributed teams more than collocated teams. The study by Suh and Shin (2010) showed that online interaction significantly affected group norms and trust in distributed teams but not in collocated teams.

Roberts et al. (2006) examined group work between face-to-face, face-to-face groups using CT, and distributed groups using CT. Group work was similar to our measure of positive social environment as it measured whether the team worked constructively, honestly, and together with all members. The research found that distributed groups had the worst group work. Their finding is explained by social presence as distributed teams had the lowest social presence, followed by face-to-face groups using CT and face-to-face groups. This suggests that CT sociability which enhances social presence would be able to increase the positive social environment for distributed teams more than collocated teams.

The paper suggests an interaction between CT sociability, proximity and learning outcomes:

H3a: CT Sociability is positively associated with self-reported learning. This effect will be stronger in learners from distributed teams as compared to collocated teams.

H3b: CT Sociability is positively associated with academic achievement. This effect will be stronger in learners from distributed teams as compared to collocated teams.

H3c: CT Sociability is positively associated with positive social environment. This effect will be stronger in learners from distributed teams as compared to collocated teams.

6.2.5 Task-related and Social-emotional Communication Activity

Many researchers have examined team communication in small groups (Germonprez & Zigurs, 2009; McGrath, 1984; Whitworth, et al., 2000). Early research on group work tended

to focus on task communication only as authors viewed group interaction as businesslike, depersonalized and task-oriented (Liu, 2002). Many researchers have observed that individuals tend to have greater task orientation using CT (Dubé & Robey, 2008; Jonassen & Kwon, 2001; Schellens & Valcke, 2006). Other researchers have found that social interaction is discouraged due to interference with the task (Chiu & Hsiao, 2010; Lipponen, et al., 2003).

On the other hand, some researchers have come to value the importance of social interaction using CT. This is considered an emerging research area in IS research (Schiller & Mandviwalla, 2007). Socio-emotional activity helps in increasing motivation and morale (Geer, 2006; Walther & Burgoon, 1992), improves decision-making and team performance (Warkentin, et al., 1997), enhances the formation of social communities (Rovai, 2002) and affects learning outcomes (Flammia, et al., 2010; Ocker & Fjermestad, 2008). Michinov and Michinov (2008) find socio-emotional activity so important to group outcomes that they suggest having face-to-face meetings during the midpoint of online learning groups to encourage the social interaction in the team.

Both task-related and socio-related activities are important for effective teams. Seminal research by Bales' (1950) led the foundation for this conceptualization. The research posits that fundamentally any small group occupies itself with two types of activities: task-related and socio-emotional activities. Groups continually divide their time between instrumental (task-related) and expressive (socio-emotional) needs. These two activities are mutually exclusive. Moreover, Bales theorizes that groups are equilibrium-seeking systems. Too much of one activity would cause a strain on the group and require the group's attention on the other activity. Basically, both instrumental and expressive needs have to be maintained in groups in order for them to be successful.

These past studies have foregrounded the importance of a perceived equilibrium, where the degree of task-related activity is similar to the degree of socio-emotional activity (Bales, 1953; Barron, 2003; de Vries, et al., 2002; McGrath, 1991). In that regard, a balance of task-

related and socio-emotional activity, termed TSAB is conceptualized. This balance is an equilibrium effect in the team which has been asserted to be crucial for outcomes. A departure from TSAB would indicate that there was either more task-related activity than socio-emotional or more socio-emotional activity than task-related. It suggests that teams are focusing too much attention on either instrumental or expressive needs, which could negatively affect learning outcomes.

TSAB has been suggested to affect self-reported learning. Benbunan-Fich and Hiltz (2003) found that both task-related and socio-emotional activities affected perceived learning. The research describes that task-related activity enhanced learning via activating specific cognitive processes. For instance, group discussion helps learners to internalize explanations provided by more knowledgeable peers. Similarly, explaining to others clarifies the learner's own understanding. On the other hand, socio-emotional activity helped to increase learner's motivation, which made them work harder and learn more. Other studies have also shown the importance of either task-related activity or socio-emotional activity for perceived learning. Jonassen and Kwon (2001) found that higher TSAB in problem-solving computer-mediated groups led to learners perceiving higher quality discussions. Carr et al. (2007) found that emotional engagement of students over the CT improved the learning process and perceptions. Less socio-emotional activity as compared to task-related activity would then cause learners to be unengaged with the learning while more socio-emotional communication as compared to task-related communication would suggest that learners would gain less knowledge from the sharing. These suggest that more TSAB would enhance self-reported learning.

H4a: TSAB will be directly related to self-reported learning.

The academic achievement of learners should also be affected by TSAB. Firstly, task-related activity would directly affect task outcomes (Warkentin, et al., 1997). Second, socio-emotional activities help to regulate team behavior in the group, keeping the group satisfied

so that they can work on the task effectively (Bales, 1950; Dubé & Robey, 2008). Bales' (1950) group equilibrium model posits that groups need to maintain a balance of task-related and socio-emotional activities in order to become successful.

Ocker and Fjermestad (2008) performed quantitative and qualitative analysis on 8 graduate student teams using CT and found that high performing groups i.e. those that received better academic grades on the project, had higher task-related activity. Moreover, this task communication was in terms of argumentation and summarization. Groups that were able to develop their ideas through debate and clarify the various viewpoints into an integrated outcome performed better. Although the study found no significant differences between the socio-emotional activity of high and low performing teams, the study reports that high performing team members "exerted effort to maintain a professional and positive demeanor as they offered opposing opinions" (p.63). It suggests that positive socio-emotional activity such as encouragement and diplomacy enhanced the team project grade. The feelings of comradeship, solidarity, care and concern for each other will enable learners to work together cohesively in a group, thereby producing better results (Kreijns et al., 2005). In view of the literature, we predict that TSAB is needed for higher academic achievement.

H4b: TSAB will be directly related to academic achievement.

TSAB will also affect positive social environment. In CSCL, there has been too much focus on the functional task rather than the social climate (Kreijns, et al., 2007). Attention to the task alone concentrates on the cognitive demands of the task and does not cultivate any relational aspects. Research has shown that students feel alienated and isolated in learning environments that are dominantly task-focused (Gunawardena, 1995; McInnerney & Roberts, 2004).

On the other hand, socio-emotional activity among members such as self-disclosure, introductions, courtesy, encouragement and exchanging views and valuing them in a group,

will engender feelings of community, trust, and a sense of belonging in the team. Moreover, learners can "overcome some of their reticence through an exchange of interests, values and ideas" (Geer, 2006, p.134). This interpersonal knowledge gained through socio-emotional activity creates bonds between group members and facilitates the development of group norms or conduct and enhances team members' emotional closeness and trusting relations in virtual teams (Robey, et al., 2000). Socio-emotional activity can also enhance the social presence in the group which will lead to a positive climate (Gunawardena, 1995; Short, et al., 1976).

However, too much socio-emotional activity over task activity may also result in group dissatisfaction and an unhealthy social climate. An emphasis on socio-emotional communication will cause strains on the task which can lead to a poor social environment (Bales, 1950; McGrath, 1984). As the interaction in learning groups are functional rather than recreational (Peña & Hancock, 2006), learners that perceive that they are engaging in too much socio-emotional activity may feel that they are neglecting the task or not learning (Chiu & Hsiao, 2010). These suggest that learners' sense of positive social environment will decrease.

Therefore, similar degrees of task-related and socio-emotional activities are crucial to the development of a positive social environment. Recent empirical results suggest likewise. In a qualitative study of 7 virtual student teams, Flammia et al. (2010) found that task and socio-emotional communication helped members develop trust relations with their teammates and improved group cohesion. Moreover, teams that did not have high socio-emotional interaction reported having a low sense of ownership for the task and regretted not paying attention to member relations. The study proposes:

H4c: TSAB will be directly related to positive social environment.

6.2.6 Interaction between CT Sociability and TSAB

The design of CT affects communication (Munkvold & Zigurs, 2007; Te'eni, 2001). In teams using CT, performing activities that are task and socio-emotional related will occur (Munkvold & Zigurs, 2007). Te'eni (2001) reviews that characteristics of CT have an action-oriented and relationship-oriented impact on communication. However, the extent of the impact is unclear.

As earlier hypothesized, CT sociability should enhance self-reported learning due to increased interaction among peer learners in the team. Moreover, if this communication is both task and socio-emotional related, two processes will occur. One, cognitive processes of learning will be triggered from the task discussion and two, from the socio-emotional communication, learners will become more motivated to complete the task well. Schellens and Valcke (2006) analyzed the content of 38 asynchronous discussion groups comprising 300 undergraduates. The research reported that 11.9% of all communication was non-task-oriented which consisted of nonsense, technical, planning, and social (e.g. "Good job!) categories. The empirical study showed that groups which had more social and task-oriented communication were able to construct knowledge better than other groups with lower social communication. This suggests that the relationship between CT sociability and self-reported learning will be greater with TSAB.

H5a: CT Sociability is positively associated with self-reported learning. This effect will be stronger with TSAB.

The relationship between CT sociability and academic achievement will also be affected by TSAB. High CT sociability by allowing learners to easily communicate enhances effort in the project task. Coupled with TSAB, whereby motivated learners work on the task, academic achievement will be high. High CT sociability which is a richer media affords more interaction in the team. The equilibrium theory from Bales (1953) suggests that members that interact with both task-related and socio-emotional content do better on the project. Members that concentrated too much on the task could have alienated other members' contribution and

involvement (McGrath, 1984) while an emphasis on building relational links neglects the work on the project, resulting in lower academic achievement.

Tutty and Klein (2008) surveyed 120 undergraduates performing a complex inquiry task focusing on the effect of media, face-to-face versus computer-mediated. The study found that computer-mediated teams had higher academic grades. Incidentally, the study also found that groups using CT had more socio-emotional communication than face-to-face groups, and more task-related communication in terms of questioning. The evidence suggests that the social interaction motivated students' to do well in the task and also the task-related questions helped students' to reflect and master the content, thereby improving their academic performance. In the same vein, the paper proposes:

H5b: CT Sociability is positively associated with academic achievement. This effect will be greater with TSAB.

Research has found that it is difficult to establish a positive learning climate in computer-mediated environments especially under time pressure (Curtis & Lawson, 2001; Johnson, et al., 2002; Walther, 2002). For instance, Walther et al. (1994) find that group communication had statistically less socio-emotional activity in time-limited studies compared to time-unlimited studies using CT. With a focus on task-related activity, social presence will decrease and learners will feel alienated from their group (Gunawardena, 1995). Johnson et al. (2002) found many interaction issues such as lack of willingness to participate, lack of planning, and conflicting schedules that affected the overall learning climate in learning groups using CT.

Curtis & Lawson (2001) performed a content analysis on both task-related activity and socio-emotional activity in asynchronous collaborative learning groups. The analysis found that 95% of all coded communication was task-related while only 5% was socio-emotional. Qualitative feedback showed that learners found it difficult to communicate with teammates

they did not know well, and were unable to build group norms such as maintaining a team work schedule. The findings suggest that emphasis on task content will hamper the development of a positive social environment.

On the other hand, even with high CT sociability, too much focus on socio-emotional activity could also lower positive social environment (Chiu & Hsiao, 2010). Despite the many avenues of interaction afforded by high CT sociability, which could increase positive social environment, TSAB can moderate this effect. If the communication is overly focused on the task or socio-emotional aspects, positive social environment will be low. The paper thus hypothesizes that greater TSAB will enhance positive social environment coupled with high CT sociability.

H5c: CT Sociability is positively associated with positive social environment. This effect will be stronger with TSAB.

6.2.7 Interaction between Proximity and TSAB

The relationship between proximity and learning outcomes is affected by TSAB (Dubé & Robey, 2008; Warkentin, et al., 1997). In general, learning is enhanced with cognitive and social processes as these processes are mutually interactive and overlapping (Maor, 2007). Earlier we predicted (Section 6.2.3) that collocated teams would have higher self-reported learning compared to distributed teams as they can clearly communicate with each other and share information and knowledge easily, and have common understanding and norms which allows members to enhance their learning. This would suggest that with better mutual understandings and clearer communication in collocated teams as compared to distributed teams, TSAB would help the team learn well.

However, other literature suggests that distributed teams can also learn equally well as collocated teams when provided with certain structures such as social, work and communication structures (Hinds & McGrath, 2006). Distance reduces non-task-related

communication (Sarbaugh-Thompson & Feldman, 1998). Hence, ensuring that there is TSAB would help the team engage in cognitive processing and group member regulation, facilitating the learning of distributed team members (Benbunan-Fich & Hiltz, 2003). Although in general collocated teams have higher self-reported learning, TSAB can offset difficulties in distributed teams. The paper suggests:

H6a: Collocated team members, as compared to distributed team members, will have higher self-reported learning. This effect will be weaker with TSAB.

Due to shared physical environments and contextual information, ease of coordination and similar cultural understandings, collocated teams will be able to integrate their ideas more easily than distributed teams and fare better on the task (Kiesler & Cummings, 2002). However, past literature suggests that TSAB is crucial for academic achievement in distributed teams (Dubé & Robey, 2008; Ocker & Fjermestad, 2008). From an analysis of 42 members of distributed work teams, Dube and Robey (2008) analyzed the paradox that "task-oriented virtual teamwork succeeds through social interactions" (p. 19). The study found that besides having task focus, building relational links helped distributed teams become more successful. Chudoba et al. (2005) compared between collocated and distributed teams for performance and found no differences between them when there was adequate social interaction. Nevertheless, we argue that academic achievement will still be higher in collocated teams as previously presented, but TSAB will pave the way for higher academic achievement for distributed learning groups (Ocker & Fjermestad, 2008). The hypothesis is:

H6b: Collocated team members, as compared to distributed team members, will have higher academic achievement. This effect will be weaker with TSAB.

Proximity enables team members to develop closer relationships and a positive social environment (Peña, et al., 2007; Powell, et al., 2004). However, socio-emotional activity may be beneficial for distributed teams as it allows members to gain shared understandings of each

other, and reduce potential misinterpretations and cultural biases (Chudoba, et al., 2005). For instance, sharing personal information allows teammates to understand each other better and work better as a team. This will be more critical in distributed teams whose members lack spatial, temporal and cultural context cues (Sproull & Kiesler, 1986). On the other hand too much emphasis on socio-emotional activity will lead to lower group climate and calls for TSAB (Bales, 1950). Thus, the paper posits that collocated teams will have higher positive social environment than distributed teams but TSAB will offset that difference in distributed teams.

H6c: Collocated team members, as compared to distributed team members, will have higher positive social environment. This effect will be weaker with TSAB.

6.3 Research Methodology

In order to investigate the phenomena, a field experiment was conducted in a project that spanned Singapore and the United Kingdom. Students from a course in Singapore and Aston, Birmingham, United Kingdom participated in the same project. Singapore students were taking the course Management Information Systems while students in the UK were taking the course Decision Support Systems. The goals of this project were for students to gain experience using CT, practice teamwork skills in virtual teams, learn about information system concepts, and develop co-authorship skills through the project collaboration.

6.3.1 Procedure

As the namelist of students who were taking the course were known before hand, students were randomly assigned to groups. Students were first emailed their team details, instructions and the URL to the system. Before the task was revealed, students were to undergo training by watching two short video tutorials that gave tips on how to use the CT and how to collaborate online. These screencasts of the CTs were to be viewed online; the weblinks are shown in Appendix C1. This period was known as the ice-breaker period, and students were

instructed to use the CT provided and start on an ice-breaker activity (a self-introduction to their teammates) to help them get to know their virtual teammates.

Next, the task was revealed at a stated time on the homepage of the CT. Students were given 3 weeks to complete the task. Students were instructed to complete the task by brainstorming (to suggest ideas and answers), an action period (to write out the report) and a revision period (to finalize and streamline answers). This framework of group collaboration is commonly used in education (Lowry & Nunamaker, 2003).

To capture the data during the field experiment, two online surveys were conducted - one midway during the project (during the action period), and one at the end of the whole project. The surveys were positioned as an online review in which students could reflect on their experiences. Marks were awarded to students who had completed each review.

6.3.2 Task

The experimental task was a complex task which required group members to discuss, negotiate and agree on a final solution (Fuchs et al., 2000). This task involved collaborative writing which is an equivocal activity (Burke, et al., 1999; Kraut, Galegher, Fish, & Chalfonte, 1992). It tested the knowledge and decision-making skills of group members and was set in the information systems domain. The task is shown in Appendix C2. The weightage of the project was 15%, the same for both courses. This weightage sufficiently motivated students to put effort in the project.

6.3.3 Experimental Manipulation

Each group was allocated to one of the 2 CTs designed for the course. The two systems were designed to differ in the level of CT sociability. The system low in CT sociability was named Co-wiki and is based on the Pmwiki software. The system high in sociability was named We-Key, and while based on the Pmwiki software was made into a Facebook application. We-

Key also had a group chat feature to allow for instantaneous chat with group members. Figure 6.2 and Figure 6.3 show screenshots of the 2 systems.

A total of 159 students participated in the project and 51 teams were formed of 3-4 persons each. Although the study intended to have collocated groups in the UK, the larger course size in Singapore (n=134) compared to UK (n=25), forced the study to form collocated groups of students in Singapore only. Distributed groups comprised students from the UK and Singapore; typically there were 2 Singapore students to 1 UK student although in one case there were 2 Singapore students to 2 UK students in a team. In sum for proximity (PRX), 75 students were in distributed teams while 80 were in collocated teams.

Students were instructed to communicate and collaborate exclusively using the CT. However, we did not restrict face-to-face interaction among collocated members due to ecological validity concerns on the natural operation of collocated groups (Peña, et al., 2007). Moreover, the final report was to be submitted on the CT, which encouraged them to make full use of the CT. In addition, we measured student's perceived media usage in the second survey. This captured the frequency of CT usage, face-to-face meetings, email usage, phone usage, and instant messaging usage.

6.3.4 Measurement Instruments

The first survey captured demographic variables, CT sociability and task-related and socio-emotional activities. The second survey captured learning outcomes and qualitative feedback about the CT and their learning perceptions. There were no repeated measures in order to minimize testing and sensitization effects (Gravetter & Forzano, 2006).

All items were rated on Likert-scales from 1 to 7, with 7 indicating the most preferred or agreed. CT sociability (SOC) scales were based on Kreijns et al. (2007) which is consistent with Study I. It included items such as "This system enables me to easily contact my teammates", "This system enables me to get a good impression of my teammates", "This

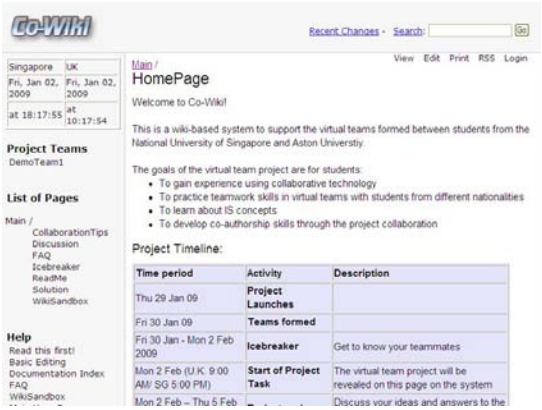


Figure 6.2 Co-Wiki Screenshot

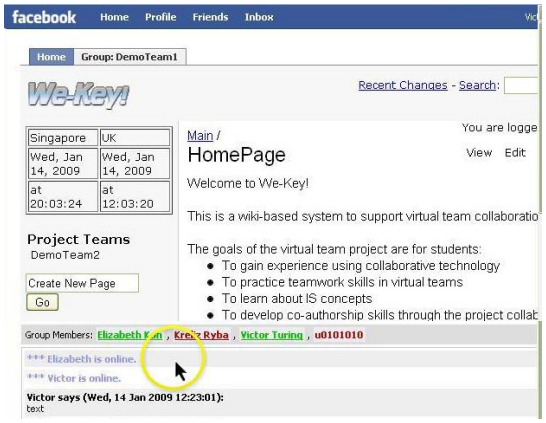


Figure 6.3 We-Key Screenshot

system allows spontaneous informal conversations", and "This system enables us to develop into a well performing team".

TSAB was operationalized in this manner: task-related activity and socio-emotional activity perception was first measured which is consistent with the conceptualization employed by Walther et al. (1994). The items were based on Bales (1950) and Green and Taber (1980). The task-related activity items were "I made suggestions about the task", "I gave information about the problem", and "I gave opinions about the task". The socio-emotional activity items were "I encouraged frequently", "I was courteous," and "Others expressed a positive opinion about your behavior". An average score for task-related activity and socio-emotional activity for each participant was calculated. Next, we measured the difference between task-related activity and socio-emotional activity. As we were only interested in the degree of difference from the center, and not the direction of the difference, the absolute values of the differences were then computed. This result provided a departure from TSAB, termed DFB, which enables us to examine the importance of TSAB.

The second survey captured learning outcomes of self-reported learning (SRL) and positive social environment (PSE) which is consistent with the other two studies in the thesis. Academic achievement (ACA) was measured using the final project grade. This was a combination of the marks from the group report and participation in the two reviews. The report was graded based on clarity, accuracy, original writing, organization, and teamwork.

Two lecturers and a teaching assistant marked the reports. The inter-rater reliability was measured based on an approximation of intraclass correlation and the result of 0.99 indicates that there is little variance among the graders in scoring the report (Ebel, 1951).

6.4 Data Analysis and Results

Partial Least Squares (PLS) was used to analyze the results. A key advantage of PLS is its ability to analyze non-normal distributions and small sample sizes. Data was analyzed at the individual level as the research was interested in the individuals' perceptions of the group rather than the group level perception. Two students did not perform both reviews and 2 outliers were found resulting in the final sample of 155 datapoints. Demographic values such as gender (GEN), age (AGE) and institute (INS) for the final sample (n=155) are shown in Table 6.1.

Table 6.1 Demographics of Participants

Variable	Category	Number (n=155)	Percentage
Gender	Male	111	71.6
	Female	44	28.4
Age	19	8	5.2
	20	10	6.5
	21	14	9.0
	22	24	15.5
	23	41	26.5
	24	37	23.9
	25	14	9.0
	26	2	1.3
	27	3	1.9
	35	1	.6
	36	1	.6
Institute	UK	23	14.8
	Singapore	132	85.2
Wiki Experience	First Time	35	21.9
	A Few Days	23	14.8
	Less than a month	28	18.1
	1-6 mths	15	9.7
	1-2 years	33	21.3
	More than 2 years	22	14.2
CT Usage	Seldom - less than 2 times	21	13.5
	Occasionally - 2-5 times	65	41.9
	Frequently - more than 5 times	69	44.5

The research calculated DFB through taking the difference between the scores of task-related activity and socio-emotional activity. This produced magnitudes ranging from -3.33 to 3.33. The absolute values of DFB were then taken and this ranged from 0, total balance, to 3.33, where there was more DFB. Table 6.2 depicts frequencies and percentages of DFB.

Appendix C3 displays the means of the interacting variables of the study.

Table 6.2 Frequencies of the Departure from Task-related and Socio-emotional Activity Balance

DFB	Frequency	Percent
0	20	12.9
0.33	37	23.9
0.67	33	21.3
1	22	14.2
1.33	17	11
1.67	7	4.5
2	10	6.5
2.33	5	3.2
3	3	1.9
3.33	1	0.6
Total	155	100

6.4.1 Measurement Model

The measurement model test includes examination of the internal consistency, convergent and discriminant validities of the research instruments. Table 6.3 reports the items and sources for SRL and PSE. Mean values and item loadings are also shown.

Table 6.3 Items for Dependent Variables

Cons-tructs	Measures	Mean (SD)	Item Loading		Source
			SRL	PSE	
Self-reported learning (SRL)					
SRL1	I increased my skills in critical thinking.	5.21 (0.94)	**0.857**	0.362	(Alavi, 1994)
SRL2	I increased in ability to integrate facts	5.31 (0.98)	**0.850**	0.429	
SRL3	I increased in ability to critically analyze issues	5.27 (0.90)	**0.818**	0.401	
SRL4	I was more confident in expressing ideas.	5.36 (1.14)	**0.762**	0.267	
SRL5	I learned to value other points of views	5.68 (1.02)	**0.752**	0.474	
SRL6	I learned to interrelate important topics and ideas.	5.26 (1.06)	**0.824**	0.464	
SRL7	I increased in understanding of basic concepts.	5.48 (0.91)	**0.467**	0.242	
SRL8	I learned factual material.	5.49 (0.88)	**0.376**	0.305	
SRL9	I learned to identify central issues.	5.40 (1.04)	**0.759**	0.280	
Positive Social Environment (PSE)					
PSE1	Teammates felt free to criticize ideas, statements, and/or opinions of others.	5.52 (1.11)	0.321	**0.558**	(Kreijns, et al., 2007)
PSE2	We reached a good understanding on how we had to function.	5.31 (1.10)	0.493	**0.806**	
PSE3	Teammates ensured that we kept in touch with each other.	4.72 (1.51)	0.383	**0.846**	
PSE4	We worked hard on the project.	5.65 (1.13)	0.433	**0.779**	
PSE5	I maintained contact with all other teammates.	4.87 (1.52)	0.267	**0.729**	
PSE6	Teammates gave personal information on themselves.	5.00 (1.38)	0.203	**0.724**	
PSE7	The team conducted open and lively conversations and/or discussions.	4.85 (1.34)	0.423	**0.825**	
PSE8	Teammates took the initiative to get in touch with others.	4.99 (1.36)	0.362	**0.861**	
PSE9	Teammates spontaneously started conversations with others.	4.79 (1.43)	0.500	**0.830**	

The individual reflective-item reliability is assessed by examining the loadings of the items with their respective construct. Most of the standardized loadings were over the acceptable cut-off level of 0.7 except for SRL7, SRL8, and PSE1 (Nunnally, 1978). These items also cross-loaded highly on each other's constructs. SRL7 and SRL8 could have poor loadings on their own construct as the items were about the learning of basic concepts and factual material which the project did not emphasize on. The project task placed students in a real-world hypothetical situation, and did not require them to learn basic facts, but rather use higher order skills. As for PSE1, criticizing other teammates might have a negative connotation and students might have been reluctant to identify their actions as such. These three items were deleted resulting in adequate internal consistency, convergent and discriminant validity as shown in Table 6.4.

Internal consistency, which is commonly measured by the Cronbach's alpha test revealed that all constructs met the criterion of 0.7 (Nunnally, 1978). Convergent validity as assessed by composite reliability and average variance extracted were higher than 0.5 (Fornell, 1982). Discriminant validity was also adequate as the construct's square root of average variance extracted exceeded the correlations between this construct and any other construct.

Table 6.4 Measurement Model Results

	CR	α	AVE	1	2	3	4	5	6	7	8	9
1. AGE	1.000	1.000	1.000	***1.000***								
2. GEN	1.000	1.000	1.000	*-0.284*	***1.000***							
3. INS	1.000	1.000	1.000	*-0.019*	*0.237*	***1.000***						
4. SOC	1.000	1.000	1.000	*0.000*	*0.098*	*0.036*	***1.000***					
5. PRX	1.000	1.000	1.000	*-0.135*	*0.140*	*0.431*	*0.047*	***1.000***				
6. DFB	1.000	1.000	1.000	*-0.011*	*-0.048*	*-0.179*	*0.019*	*-0.118*	***1.000***			
7. SRL	0.927	0.909	0.647	*-0.058*	*-0.199*	*0.291*	*-0.043*	*0.103*	*-0.050*	***0.804***		
8. ACA	1.000	1.000	1.000	*0.073*	*0.105*	*0.448*	*0.042*	*0.295*	*0.009*	*0.220*	***1.000***	
9. PSE	0.935	0.921	0.642	*-0.215*	*0.120*	*0.226*	*0.099*	*0.200*	*-0.115*	*0.471*	*0.336*	***0.801***

Notes: CR= Composite Reliability. α = Cronbach's Alpha. AVE= average variance extracted. Italics = Correlations betwen constructs. Bold = square root of AVE.

6.4.2 Sociability and Demographic Variables

One-way ANOVAs were performed to test the manipulation and the effect of the demographic variables on learning outcomes. A manipulation check was done for SOC with the system used. Both systems differed in terms of perceived sociability, F=3.595, p=.06. The

mean sociability for Co-wiki was 3.71 while We-Key was 4.05. This suggests that SOC was successful manipulated.

As this was a field experiment, several controls were measured to minimize spurious effects. One-way ANOVAs were calculated between the learning outcomes and the controls: age, gender, wiki experience, institute, media usage (CT usage, face to face meetings, email usage, phone usage, and instant messaging usage). The relationship of media usage and all learning outcomes were non-significant. This was removed in the model while the rest of the significant controls were retained.

6.4.3 Structural Model

A two-stage procedure was followed to analyze the results of the study. The main effect was analyzed followed by the interaction effect, which is consistent with the literature (Henseler & Fassott, 2010).The main effects model (1A) resulted in an R square of 18% for SRL, 23% for ACA, and 12% for PSE. The interaction effects model (1B) was then calculated and the R square of all the learning outcomes improved by 2% on average. The R square of SRL became 20%, ACA 24%, and PSE 15%. This indicates that the interaction model explains more of the variance than the main effects model. Using the two-tailed test of significance, 7 relationships were statistically significant, 3 where close to significance while the other 8 were non-significant. The structural model results are shown in Table 6.5.

6.4.4 Direct Effects

The controls, gender, age and institute were significant for several learning outcomes. These relationships remained significant throughout the two models. Males had higher SRL and PSE than females. However, females had higher ACA than males. In addition, AGE affected SRL only and younger learners perceived they learnt more. These findings on gender and age are consistent with previous studies that predict that learner characteristics affect learning outcomes (Hong, 2002). The institute of study had a large effect on SRL, ACA and PSE.

Table 6.5 Structural Model Results

Relationships	Model 1A (Main effects)			Model 1B (Interaction)		
	beta	T	p-value	beta	t	p-value
CT Sociability						
SOC -> SRL	-0.023	0.596	-	-0.007	0.201	-
SOC -> ACA	0.011	0.398	-	0.025	0.743	-
SOC -> PSE	0.090	1.838	0.068	0.217	3.197	0.002
Proximity						
PRX -> SRL	-0.035	0.963	-	-0.031	0.836	-
PRX -> ACA	0.145	2.996	0.003	0.146	2.778	0.006
PRX -> PSE	0.088	1.808	0.073	0.190	2.305	0.023
Task Social Activity Balance						
DFB -> SRL	-0.009	0.345	-	0.008	0.243	-
DFB -> ACA	0.156	3.134	0.002	0.114	2.287	0.024
DFB -> PSE	-0.041	1.002	-	-0.068	1.217	-
Interaction construct/term						
SOC*PRX -> SRL				-0.075	1.540	0.126
SOC*PRX -> ACA				0.000	0.010	-
SOC*PRX -> PSE				-0.199	2.123	0.035
DFB*SOC -> SRL				-0.077	1.620	0.107
DFB*SOC -> ACA				-0.060	1.391	-
DFB*SOC -> PSE				-0.175	2.864	0.005
DFB*PRX -> SRL				0.104	2.033	0.044
DFB*PRX -> ACA				0.061	1.566	0.119
DFB*PRX -> PSE				0.045	0.969	-
Controls						
GEN -> SRL	-0.148	2.749	0.007	-0.140	2.400	0.018
GEN -> ACA	0.113	2.298	0.023	0.109	2.140	0.034
GEN -> PSE	-0.200	3.379	0.001	-0.177	2.942	0.004
AGE -> SRL	-0.324	2.954	0.004	-0.338	3.018	0.003
AGE -> ACA	0.023	0.812		0.012	0.410	-
AGE -> PSE	0.000	0.007		-0.025	0.519	-
INS -> SRL	0.380	5.988	<.001	0.355	5.539	<.001
INS -> ACA	0.391	6.594	<.001	0.386	6.331	<.001
INS -> PSE	0.179	2.514	0.013	0.139	2.132	0.035
Learning Outcomes	R^2			R^2		Change
SRL	0.181			0.199		0.018
ACA	0.234			0.240		0.006
PSE	0.117			0.151		0.034

Students from the Singapore University had higher learning outcomes than students from the UK University. A reason for this might be the different motivational levels of students from the institutes. The lecturer of the UK University disclosed that students in the UK institute did not place as high emphasis on grades as students in the Singapore institute.

SOC directly affected PSE only. The path coefficient of SOC on PSE is 0.217, p=.002. The relationships between SOC and SRL and ACA were not supported in the model. As for proximity, proximity did not affect SRL. However, proximity affected ACA, the path

coefficient is 0.146, p=.006. The relationship between proximity and PSE was also significant, path coefficient 0.190, p=.023. This indicates that collocated teams did better in terms of ACA and PSE as hypothesized but not in terms of SRL.

A post-hoc analysis was carried out to analyze the relationship between PSE and ACA, and the relationship between SRL and ACA. Past literature has suggested that PSE helps to enhance ACA while SRL is a possible measure for APA (Rovai, 2002). Consistent with past literature, PSE directly influenced ACA, F = 2.637, p <.001. Similarly, SRL affected ACA although with lower significance, F = 2.101, p=.004.

From model 1B, the direct effect of TSAB on SRL was not supported. However, there was a significant relationship between TSAB and ACA, but not in the direction hypothesized. Higher activity unbalance resulted in higher ACA, beta = 0.114, p=.024. A post-hoc analysis was performed to understand the task-social direction by employing DFB towards task activity, a continuous variable with higher task activity on one end, and socio-emotional activity on the other end. The analysis revealed that higher task-related activity led to increasing ACA. This was significant at beta 0.157, p=.001. As for the direct effect of TSAB on PSE, this was not statistically non-significant. TSAB did not affect PSE as predicted.

6.4.5 Interaction Effects

The paper first analyzes the results for the interaction relationship between SOC, PRX and the learning outcomes. There was an interaction effect between SOC, PRX and SRL and PSE but no interaction between SOC, PRX and ACA.

The path coefficient between the interaction SOC, PRX and SRL was close to significance at -0.075, p=.126. Figure 6.4 illustrates the relationship. The result shows that SOC is inversely related to SRL which is reverse to our hypothesis. However, distributed teams had higher SRL as compared to collocated teams. High SOC reduced the differences in SRL between distributed teams more than collocated teams which is in line with our hypothesis. Distributed

teams had higher SRL as compared to collocated teams with use of high SOC. This shows that H3a is partially supported.

For PSE, there was an interaction between SOC and PRX, path coefficient -0.199, p=.035. Figure 6.7 illustrates the relationship. The results show full support for H3c. Overall, SOC was positively related to PSE and this effect is stronger for distributed teams as compared to collocated teams. High SOC enhances PSE for distributed teams more than low SOC while high SOC had a weaker impact on collocated teams.

The interaction between SOC, task-related and socio-emotional communication and learning outcomes is now examined. For hypothesis 5a, the results reveal that TSAB moderated the relationship between SOC and SRL. The path coefficient was -0.077 and mildly significant at p=.107. Contrary to our hypothesis, the results show that SOC is inversely related to SRL. However, in conditions of high SOC, TSAB enhanced SRL. The relationship between SOC and SRL is stronger with TSAB. This relationship is illustrated in Figure 6.5. The figure shows that more TSAB, represented by less departure from TSAB, enhances SRL with high SOC. This provides partial support for H5a. Interestingly, TSAB did not seem to affect low SOC, and SRL seemed to be higher with low SOC.

There was no interaction between SOC, TSAB and ACA. Hence, there was no support for H5b, suggesting mixed effects for SOC and TSAB on ACA.

There was an interaction effect between SOC, TSAB and PSE. The beta was -0.175 and significant at p=.005. High SOC improved PSE as predicted, and this relationship was stronger with more TSAB. Figure 6.8 depicts the relationship. H5c is fully supported.

Lastly, the paper analyzes the interaction between proximity, task and socio-emotional communication and learning outcomes. TSAB moderates the relationship between proximity and SRL. From model 1B, the path coefficient for DFB*PRX was 0.104 and significant at p=.044. Figure 6.6 illustrates the relationship. The results reveal that collocated teams had

higher SRL but this effect was moderated with TSAB as more TSAB, as represented by less departure from TSAB, resulted in higher SRL for distributed teams. In other words, TSAB weakened the effect of PRX on SRL on collocated teams while strengthening the effect on distributed teams. In fact, distributed teams with more TSAB had higher SRL. This provides support for H6a.

There was an interaction effect between PRX, TSAB and ACA. The path coefficient is 0.061 and is close to significance at p=.119. Figure 6.9 illustrates the results. Collocated teams did better than distributed teams as hypothesized and this effect was weaker with TSAB. In other words, TSAB reduced the differences between distributed and collocated teams for ACA. Hypothesis 6b is supported. Interestingly, although more balanced TSA reduced the differences in distributed and collocated teams, less TSAB, as represented by greater departure from TSAB, resulted in higher overall ACA for all teams.

For PSE, there was no significant interaction between TSAB and PRX.

Last but not least, a post-hoc analysis of a 3-way interaction was performed between SOC, PRX and TSAB on all 3 learning outcomes. The results for SRL, ACA and PSE were all non-significant.

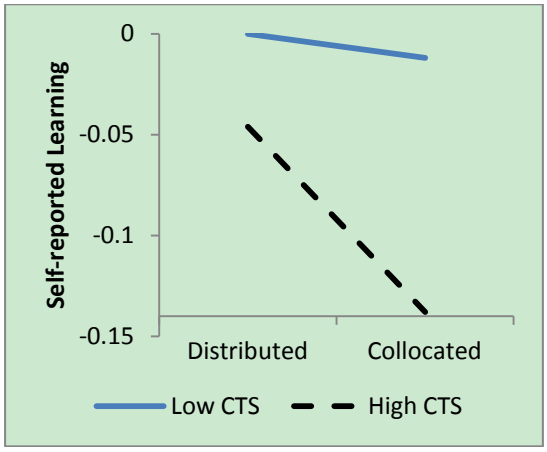


Figure 6.4 Interaction between CT Sociability, Proximity and Self-reported Learning

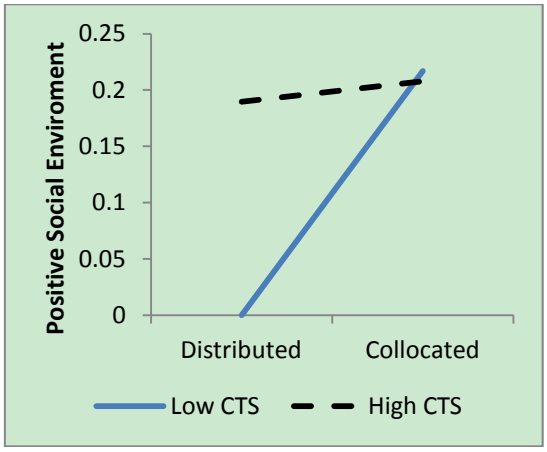


Figure 6.7 Interaction between CT Sociability, Proximity and Positive Social Environment

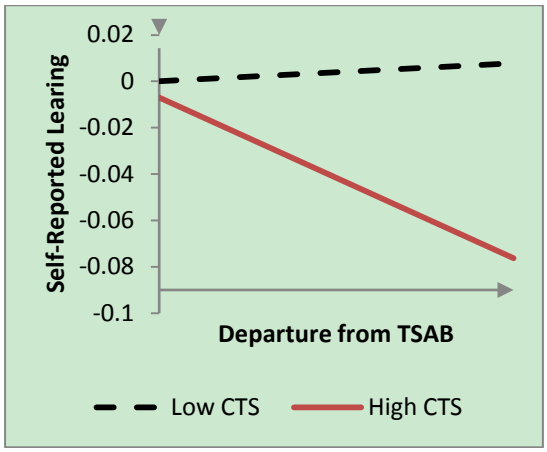


Figure 6.5 Interaction between CT Sociability, TSAB and Self-reported Learning

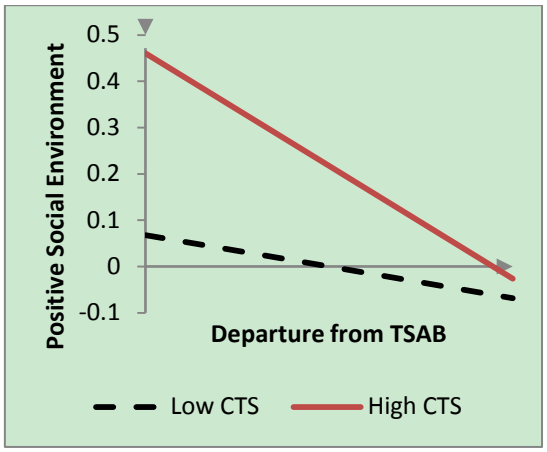


Figure 6.8 Interaction between CT Sociability, TSAB and Academic Achievement

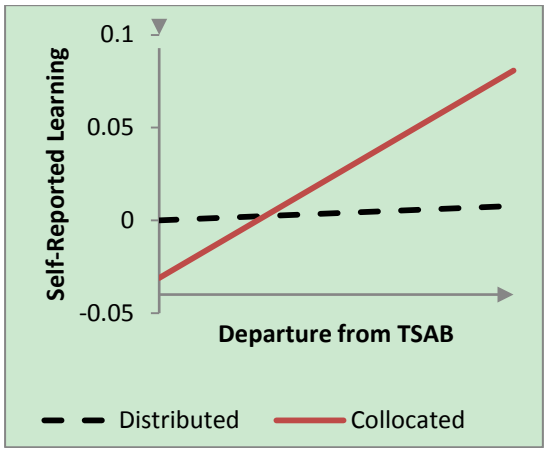


Figure 6.6 Interaction between Proximity, TSAB and Self-reported Learning

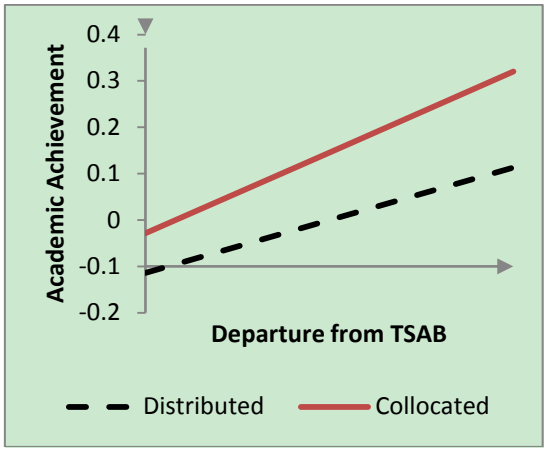


Figure 6.9 Interaction between Proximity, TSAB and Academic Achievement

6.5 Discussion

The data has revealed mixed results for the model with several interesting observations. A total of nine hypotheses were supported, of which 2 were partially supported. One hypothesis was supported in the reverse direction. Table 6.6 summarizes the findings. The arrows depict the proposed relationships while the arrows in brackets represent the significant findings in the data if the direction found was opposite to what we had proposed. We now deliberate on the findings.

Table 6.6 Hypotheses Summary and Results

Endogenous Variable	CT Sociability	Proximity	Task Social Activity Balance	Hypothesis Supported
H1a: Self-reported Learning	↑ High			No
H1b: Academic Achievement	↑ High			No
H1c: Positive Social Environment	↑ High			Yes
H2a: Self-reported Learning		↑ Collocated		No
H2b: Academic Achievement		↑ Collocated		Yes
H2c: Positive Social Environment		↑ Collocated		Yes
H3a: Self-reported Learning	↑ High (↓)	↑ Distributed		Partial
H3b: Academic Achievement	↑ High	↑ Distributed		No
H3c: Positive Social Environment	↑ High	↑ Distributed		Yes
H4a: Self-reported Learning			↑ Balance	No
H4b: Academic Achievement			↑ Balance (↓)	No, sig in opp. dir
H4c: Positive Social Environment			↑ Balance	No
H5a: Self-reported Learning	↑ High (↓)		↑ Balance	Partial
H5b: Academic Achievement	↑ High		↑ Balance	No
H5c: Positive Social Environment	↑ High		↑ Balance	Yes
H6a: Self-reported Learning		↑ Collocated	↓ Balance	Yes
H6b: Academic Achievement		↑ Collocated	↓ Balance	Yes
H6c: Positive Social Environment		↑ Collocated	↓ Balance	No

6.5.1 CT Sociability

The results reveal various effects of CT sociability on learning outcomes. For the direct effect, CT sociability was not associated with self-reported learning or academic achievement. However, CT sociability enhanced positive social environment as hypothesized. CT sociability provides passive and interactive methods for members to share information which increases social presence and a positive learning climate.

There are several possible reasons for the non-significant relationship between CT sociability and self-reported learning. First, although CT sociability promoted more interactions among

learners, the learner–learner interaction developed students' online collaboration skills rather than learning per se. Past research has reported that online collaboration may not provide greater understanding of learning materials but rather enhance learner's collaboration skills and IT skills (Arbaugh & Benbunan-Fich, 2007).

Second, the CT itself could have posed user difficulties for learners, chief of which is complexity. The CT with high sociability was higher in complexity than the CT with low sociability. Learners found that the We-Key system was slightly complicated to use as it was loaded on the Facebook platform and not very flexible. This could have reduced the amount of information shared in teams using high CT sociability, and self-reported learning would have decreased. Nevertheless, training was provided for students through video screencasts and online guides. Moreover, the survey was taken almost 1.5 weeks after the project was launched which gave students sufficient time to adapt to the CT. These measures should have reduced the complexity of the CT with high sociability.

As for the non-support for the relationship between CT sociability and academic performance, the cognitive model of media choice (Robert & Dennis, 2005) provides a theoretical explanation. High CT sociability while providing motivation for learners to perform the task also presents a lower level of reprocessability. As learners have a limited ability to process information, they are unable to evaluate all the messages they receive. Thus, high CT sociability may allow information overload to occur due to higher peer interactions and knowledge exchange. Information overload lowers academic performance and is a common issue in past empirical research (Chou & Min, 2009; Eom, et al., 2006).

In addition, the type of communication that is facilitated by CT sociability could have affected the results. Although CT sociability provides more learner-to-learner interactivity, the content of learner's communication is also important for self-reported learning and academic achievement. Studies have shown that the depth and breadth of information sharing (Chou & Min, 2009) and the dynamics of problem-solving groups (Chiriac, 2008) are

important for learning outcomes. The type of communication in terms of task and non-task could also affect self-reported learning and academic achievement; this will be discussed in the subsequent section.

6.5.2 Proximity

Proximity was found to be positively related to academic achievement but not to self-reported learning. The findings reveal a greater distinction between self-reported learning and academic achievement. Even though both constructs deal with the cognitive processes of learning, self-reported learning is induced more from peer interaction and contribution while academic achievement measures how learner's understood the project, summarized and integrated valuable points, and participated in the task. Despite facing geographical, temporal and cultural challenges, members in distributed teams could have learnt as well as collocated learners. This could be due to the diversity of opinions among distributed team members who originate from different locations, time zones and cultures. Past research has shown that one of the merits of virtual teams is in tapping the expertise of diverse members. This diversity enables the sharing of more divergent ideas and viewpoints, resulting in higher learning (Robey, et al., 2000). This explains why distributed and collocated learners had similar levels of self-reported learning.

However, the diversity of opinions could have posed problems in integration and organizing the report as posited by integrative complexity (Chidambaram & Tung, 2005; Suedfeld, Tetlock, & Streufert, 1992). Collocated teams with less diverse viewpoints might have found it easier to surmise and provide a connected flow to their report which resulted in their higher academic grades. In contrast, distributed teams with diverse viewpoints would face more difficulties connecting and integrating their report, resulting in lower academic achievement.

The hypothesis of the relationship between proximity and positive social environment was supported. The study demonstrates that collocated teams had higher positive social environment than distributed teams even with the use of CT. This highlights the relative

advantages of communicating, understanding and coordinating in collocated teams which helps to engender closer bonds and a positive climate.

6.5.3 Interaction between CT Sociability and Proximity

An interaction effect was found between CT sociability, proximity and two learning outcomes, self-reported learning and positive social environment but not academic achievement. For self-reported learning, partial support was shown for the hypothesis as the results showed that CT sociability had a stronger effect on distributed teams as compared to collocated teams. However, high CT sociability did not enhance self-reported learning as hypothesized. Rather, the reverse was shown. As suggested earlier, although high CT sociability fostered greater communication and sharing, learners could have gained collaboration skills and did not learn as much content and critical thinking skills which lowered their self-reported learning. Nevertheless, distributed teams were still advantaged by high CT sociability more than collocated teams as coming from diverse backgrounds they were able to share unique perspectives and gain more knowledge from each other, which was facilitated by CT design.

There was no significant interaction effect between CT sociability, proximity and academic achievement. This suggests that academic performance for distributed or collocated teams with the use of different CT sociability will be similar. In fact, the average grades of distributed team members that used low and high CT sociability were similar at 11.32 and 11.40 respectively while the grades of collocated team members for both high and low CT sociability were slightly higher at 12.2 and 12.29 respectively. Although the paper expected that high CT sociability as compared to low CT sociability in distributed teams will lead to increased academic achievement, the quality of information shared and the ease of organizing it was not taken into account. Distributed teams using low CT sociability have fewer spaces for interaction and greater difficulties in information exchange due to geographical, temporal and cultural differences. Yet, due to their diverse background, they could contribute better

quality points even though they contribute less information. With little but adequate information, this is then easily integrated into an accurate, clear and organized report as explained by integrative complexity. On the other hand, using high CT, distributed team members could have shared too much information which was not well organized into the final report. This resulted in distributed team members with low CT sociability having similar academic grades as distributed team members with high CT sociability. This finding is consistent with other past research (Chidambaram & Tung, 2005).

The results showed full support for H3c as CT sociability directly influenced positive social environment and the effect was stronger on distributed teams as compared to collocated teams. Interestingly, although high CT sociability reduced the differences in positive social environment between distributed and collocated teams, collocated teams had marginally higher PSE than distributed teams. This implies that the effect of proximity on positive social environment is dominant as compared to the effect of CT sociability on positive social environment. Collocated team members can identify and trust each other based simply on the fact that they are geographically, temporally and culturally similar (Bryne, 1971) and do not need additional technological features to help build their social climate. Furthermore, CT sociability is more salient for distributed teams as compared to collocated teams. This finding is consistent with past literature that has reported that technology characteristics can improve learning outcomes for distributed teams (Cortesi, 2001; Daly-Jones, et al., 1998; Janssen, Erkens, Kanselaar, & Jaspers, 2007)

6.5.4 TSAB

The hypotheses for the direct effect of TSAB were all unsupported. First, although the direction was correct, the direct relationship between TSAB and self-reported learning was non-significant. It suggests that all amounts of task-related and socio-emotional activities are important to self-reported learning. Perhaps any amount of communication behaviors has a part to play in learning. This could explain why educational researchers examine all these

communication behaviors in dialogic argumentation which promotes learning, without any emphasis on TSAB (Baker, et al., 2007; de Vries, et al., 2002).

The relationship between TSAB and academic achievement was statistically significant, albeit in the opposite direction from the hypothesis. Post-hoc analysis revealed that rather than a balance of both types of communication, task activity enhanced academic achievement. This suggests that sharing of socio-emotional content such as encouragement was not as helpful to completing the task well as much as task information such as facts and opinions. A possible reason is that the relationship is not as direct as previously hypothesized. Having TSAB alone may not directly lead to higher academic outcomes. Other situational factors need to be accounted for. This paper has identified 2 such factors which will be elaborated on subsequently.

Lastly, positive social environment did not improve with TSAB. Although the direction of the relationship was correct, the relationship between TSAB and positive social environment was statistically non-significant. This suggests that less TSAB could enhance the learning climate as well as more TSAB. An imbalance towards greater socio-emotional activity could lead to higher positive social environment as learners pay attention to relational needs which helps them feel connected to others. On the other hand, an imbalance towards greater task activity could also affect the social climate. This can be explained by the purpose of the team. As the current study was a student project team tasked to complete a report, a greater departure from TSAB towards task activity might have led students to feel glad that they are completing their task, which improved their positive social environment.

Furthermore, the lack of support for the relationship between TSAB and learning outcomes may be informed by other social context inputs. As previously theorized, TSAB should also moderate the effects of the social context on outcomes. These are now examined.

6.5.5 Interaction between CT Sociability and TSAB

TSAB moderated the relationship between CT sociability and two learning outcomes, self-reported learning and positive social environment but not academic achievement.

The relationship between CT sociability and self-reported learning was moderated by TSAB. This was partially in the direction predicted. Contrary to our prediction, low CT sociability led to high self-reported learning, which is consistent with the direct effect found earlier. Nevertheless, with the use of high CT sociability, TSAB increased self-reported learning, which is in line with our prediction. This indicates the importance of TSAB in increasing self-reported learning when high CT sociability is available.

In addition, TSAB moderated the relationship between CT sociability and positive social environment. High CT sociability led to high positive social environment and TSAB enhanced this effect. The relationship was significant in the direction predicted. It suggests that an imbalance of task-related and socio-emotional activities will inhibit the development of a positive social environment in learning groups.

Lastly, TSAB had no effect on the relationship between CT sociability and academic achievement. This indicates that CT sociability and TSAB does not affect academic achievement. As suggested by the cognitive model of media choice, teams could have generated too much information with high CT sociability which caused information overload and affected their integration. All these information shared, be it equal amounts of task-related or socio-emotional activities, needs to be made cognizant to team members. However, as the cognitive load was too high for members, they were unable to properly process all the content and incorporate their opinions and points into a cohesive report. On the other hand, low CT sociability, which can be considered a lean media, allows learners to focus on the project report, and not get distracted with off-task topics, which leads to similar academic grades as learners using high CT sociability. This has been observed in past research (Chiu & Hsiao, 2010).

6.5.6 Interaction between Proximity and TSAB

TSAB moderated the relationship between proximity, self-reported learning and academic achievement but not positive social environment. The results reveal that collocated teams had higher self-reported learning as compared to distributed teams but TSAB weakened the effect on collocated teams. In other words, self-reported learning was enhanced when distributed teams had TSAB. Having TSAB bridges the distance in distributed team members, allowing them to engage in cognitive processing and group member regulation, which facilitates their learning.

Similarly, the relationship between proximity, TSAB and academic achievement was supported in the direction hypothesized. Collocated teams performed better than distributed teams but this effect was weaker with TSAB. Greater TSAB reduced the differences in academic achievement between collocated and distributed teams. However, the results show that academic achievement was overall higher with a greater departure from TSAB. As shown earlier from the main effect, academic achievement was enhanced by greater imbalance of TSAB, as higher task-related activity influenced the academic achievement. Nevertheless, the results show that TSAB is more important for distributed teams; conceivably more TSAB could lead to distributed teams doing better than collocated teams.

There was no significant interaction between positive social environment, proximity and TSAB. Although collocated teams had higher positive social environment than distributed teams, TSAB had no stronger effect on distributed teams. This possibly suggests that the effect of proximity outweighs the mitigating effects of the type of communication. Having more TSAB does not help to improve distributed team's positive social environment as members lack common ground, mutual understanding and shared cultural backgrounds.

Last but not least, this study found an unexpected relationship between two learning outcomes, positive social environment and academic achievement. Post-hoc analysis revealed that positive social environment led to higher academic achievement. Positive social

environment builds the social climate of the team which motivates team members and enhances their collaboration and learning, subsequently leading to higher academic achievement. This is in line with past studies that have examined socio-related outcomes as a mediator of performance outcomes (Lurey & Raisinghani, 2001). The finding suggests that CT sociability, proximity and TSAB could affect academic achievement indirectly through positive social environment.

6.6 Implications and Limitations

The research has both theoretical and practical implications. A key contribution of the study is that it has shown the importance of TSAB in both theoretical and empirical aspects. This study has shown how communication, in terms of TSAB interacts with several input factors. While earlier works have examined task-related and socio-emotional activities separately, this paper breaks new theoretical ground by conceptualizing the importance of TSAB. The data has shown how TSAB has affected self-reported learning, academic achievement and positive social environment. For instance, TSAB is instrumental to self-reported learning with the use of low CT sociability, which is consistent with past literature (Fjermestad, 2004). Further research can examine how TSAB affects dependent variables deemed relevant and important in the reference disciplines of education and small group literature. The current study examined two fundamental aspects of communication, task-related and socio-emotional. Further research could examine other types of communication such as communicative social actions (Germonprez & Zigurs, 2009; Habermas, 1976) to shed light on communication's role in affecting team outcomes.

This empirical study is one of the few studies that have directly compared distributed and collocated teams instead of examining distributed teams only (Connaughton & Shuffler, 2007). This allows us to thoroughly distinguish the effects of proximity (Cramton, et al., 2007). The findings reveal that collocated teams using CT still have an edge over distributed teams. Collocated teams had higher academic achievement and positive social environment as

compared to distributed teams. Nevertheless, CT sociability and TSAB helped distributed teams improve their outcomes. These suggests the importance of choosing CT with appropriate sociability and also highlights that distributed team members should be aware of the type of communication content prevalent in the team.

In addition, the research provides practical contributions for CT developers, educators and learners using CT in distributed and collocated environments. For CT developers, the research has shown the CT sociability enhances the positive social environment of learning groups, which subsequently influences academic achievement. However, contrary to our hypothesis, low CT sociability enhanced self-reported learning. The reverse finding for CT sociability and self-reported learning suggests that CT sociability needs to be designed in a way that does not distract from learning. The research observed that the complexity of the CT might have affected the self-reported learning. Future CT sociability designs need to be mindful of the possible contentions in developing CTs. Although designing CTs with more avenues for interaction can provide more planned and opportunistic meetings among team members, the CT can become overly complicated to use. It suggests the need for simple intuitive user interfaces such as one screen for all messages. Some development of this kind is seen in Inbox2 (www. inbox2.com), a social email application that combines all online communication into a single web-based application.

Furthermore, the findings reveal that learning outcomes are improved when CT sociability is used with TSAB. In that regard, CTs can be designed to facilitate such communication. For instance, a weekly poll of team members' perceived level of task-related activity and socio-emotional activity can be incorporated into the CT. After working for a week on the task, team members log into the CT and answer a poll asking, "Have you contributed information to the project?" and "Have you encouraged your team members?". The TSAB status can be calculated by aggregating results of team member answers which is then displayed. This can provide impetus for teams to enhance whichever activity they are lacking in. Another possible

design would be to employ text crawlers in the CT to scan all text and identify those that are task-related and those that are socio-emotional, and capture this information using a cleverly designed indicator. This design will be less obtrusive to the team but require accurate algorithms.

For educators, the results show that CT sociability while not directly affecting self-reported learning, and academic achievement, does affect positive social environment. If this is a key learning outcome for educators, CT higher in sociability should then be used. A positive learning climate can be important especially for troubled students who may be facing problems at home and even disabled students who require a conducive learning space. The use of high CT sociability would not only help them learn but give them more pleasant experiences in learning by forging a positive social environment. Moreover, the findings also highlight the effectiveness of using CTs for collocated teams. Collocated teams fared better overall than members in distributed teams which suggests the viability of using CT for group learning in blended learning courses.

This research also has implications for learners using CT in distributed and collocated environments. For distributed learners, the study suggests that certain structures can improve outcomes. To enhance positive social environment, learners should initiate the use of CT with high sociability. To increase self-reported learning and academic achievement, learners should ensure TSAB. For example, when sharing task information, they can add a line of personal information such as their current working environment or how they feel. This will promote more socio-emotional activity in the task-oriented virtual environment which will subsequently enhance self-reported learning.

As with all empirical studies, this research has several limitations. First, two systems were designed to represent high and low CT sociability. These two systems could also have been different in other characteristics. One issue was the slower loading time of the system with high CT sociability. This was due to high system loads when more students used the CT, the

additional group chat feature, and the integrated design of the system on Facebook. In contrast, the system with low CT sociability loaded relatively fast without the need to linkup with other features even with high usage. This could have affected members' ability to communicate with the high CT sociability system. Another difference could be the complexity of the CT as highlighted earlier. High CT sociability could have seemed more complex to use as it contained more features. Nevertheless, the manipulation check for CT sociability was successful, and the two systems still represented high and low sociability. Further research could look at other characteristics of the two systems such as loading times and complexity as well as improving the usability of high CT sociability systems.

Another limitation is the use of other media besides the CT provided. In both collocated and distributed conditions, students were instructed to use the CT only; however, they could have used other media. Also, collocated members could have met physically face-to-face to do their project with little use of the CT. This was controlled for in the study as students were asked to report on their usage of other media. The effects of other media use on learning outcomes were found to be non-significant. Unfortunately, some students might not have reported their use of other media. While this may be so, the project was designed in such a way that the final deliverable, a report, had to be typed in the CT on the workspace allocated for them. This ensured that students would definitely need to use the CT. Based on personal correspondence with the students, we believe that the CT provided was the dominant media of use.

Team configuration could also have impacted outcomes. Although the research intended to have equal subgroups, the number of students enrolled in the course did not accommodate this. Most distributed teams had two members from one country and one member from the other. Subgroup imbalance could have led to other unintended consequences (O'Leary & Cummings, 2007). Future research could examine the impact of subgroup imbalance on learning outcomes.

Lastly, this study was limited in that it did not include a pure face-to-face condition. This would further help to illuminate the differences in traditional face-to-face, blended and distance learning. Other researchers can perform such a comparison. Nevertheless, this study takes place in an authentic environment with real-life short-term student project teams and compares between the collocated and distributed conditions with relevant contributions.

6.7 Concluding Remarks

The changes of our world have seen a rise of more sociable CT and the use of distributed teams. In education, the demand for such sociable CT and blended learning calls for an examination of the use of CT in collocated collaborative learning groups. This paper examines these two social contexts and determines their effectiveness in terms of the learning outcomes, self-reported learning, academic achievement and positive social environment. Nevertheless, in CSCL, collaboration, communication, and social context are crucial components. In this study, we investigated the interacting effects of the social context, communication and learning outcomes. In addition, we conceptualized that CT sociability and proximity are affected by TSAB, consisting of the fundamental types of communication processes, task-related and socio-emotional activities.

The study sought to address three questions: (1) how does the interplay of CT sociability and proximity affect learning outcomes? (2) What is the effect of TSAB on learning outcomes? (3) How is the relationship between the social context and learning outcomes affected by TSAB? Based on a field experiment of 159 students who were randomly assigned to two different CT conditions and who were distributed across Singapore and the United Kingdom, the results reveal varying support for our hypotheses. High CT sociability enhanced positive social environment while collocated team members using CT did better than their distributed counterparts in terms of academic achievement and positive social environment. The importance of an equilibrium in group activity as shown through TSAB is also deliberated on. There was no clear-cut advantage of TSAB on learning outcomes, rather TSAB interacted

with the social context in affecting outcomes. More TSAB enhanced the self-reported learning and positive social environment for distributed teams while more TSAB enhanced positive social environment with high CT sociability.

Several contributions have emerged from this research. First, the study shows that CT sociability is important for the development of a social climate. This has implications for future CT development and also in the selection of CT for various functions. In addition, the salience of proximity is shown despite growing occurrences of distribution in global virtual teams. This provides evidence for the advantages of collocated teams in blended learning. Nevertheless, the research contributes to the distributed team literature by pinpointing areas in which CT sociability and TSAB can enhance outcomes in distributed teams. Furthermore, the study demonstrates the importance of both task-related and socio-emotional communication in time-limited computer-supported learning groups which has typically been ignored in IS and education research.

As quoted in Kiesler and Cummings (2002), collaboration "is a body contact sport" (p. 57). Generally perceived to be detrimental without face-to-face contact, the study has shown that collaboration can be facilitated with CT sociability, proximity and TSAB. The interaction of the social context and the communication component enhances the learning outcomes of self-reported learning, academic achievement and positive social environment. This research should prompt future work on group collaboration, CT design, blended learning and distributed teams. Indeed, CT could augment collaboration and turn it into a "virtual contact sport".

Chapter 7: Discussion

The three studies have collectively shown how the technology and learner dimensions of the social context, and task and socio-emotional communication activities have affected learning outcomes. This discussion begins by re-capping the theoretical focus and development of the three studies, and explaining the findings in terms of the overall relationships highlighted as salient and the specific constructs that have enhanced learning outcomes. Based on the integral understanding of the findings, the theoretical framework of CT effectiveness is refined.

7.1 An Integral Understanding of Findings

Does the use of CT affect learning outcomes in groups? This study examines the overarching research question by focusing on the learning outcomes of learners as they collaborate in groups for team projects. Three studies were designed to highlight each element in the theoretical framework conceptualized. These studies examined different but connected theoretical parts to build a chain of evidence for CT effectiveness. In line with the functional and psychodynamic lenses, three other research questions were addressed: Do CT characteristics and learner characteristics affect learning outcomes? How does the interplay of CT characteristics and learner characteristics affect learning outcomes? What are the roles that task-related and socio-emotional communication processes play in affecting learning outcomes?

The interplay of CT characteristics and learner characteristics is the focus of Study I. This study established the foundation for the investigation of a new breed of CTs utilized in student project teams. Study I examined the interplay between the CT characteristics, sociability and visibility, and the learner characteristics, age and gender using a quasi-experiment. Based on 141 usable responses, the research found direct and moderating effects. CT sociability improved process satisfaction and positive social environment while CT visibility enhanced academic achievement and solution satisfaction of learners. Males had

higher solution satisfaction while older learners had higher academic achievement. Moreover, younger learners had higher academic achievement with high CT sociability as compared to older learners. On the other hand, females were more satisfied with the solution with public visibility as compared to males.

Subsequent studies also examined the interplay of the two dimensions but from a different theoretical focus. Study II placed the spotlight on communication processes in wiki-based teams. The study introduced the role of task-related and socio-emotional communication activities. It conceptualized that these two communication activities have a direct impact on learning outcomes. Two surveys were conducted with 45 and 86 different students respectively. In both surveys, a positive and significant direct effect was found between task-related activity and several learning outcomes. Interestingly, socio-emotional activity was positively associated with all learning outcomes except for academic achievement. In addition, the effect of the learner characteristics, wiki experience, perceived instructor support, age and gender, on the communication process was examined. Communication activity was found to be higher with greater instructor support, older learners and males.

Study III examined the social context (technology and learner dimensions), the communication process and the learning outcomes which were highlighted in previous studies. A quasi-experiment was conducted with 155 responses from students who used two different CTs in a project that spanned Singapore and the United Kingdom. Similar to Study I, this study provided evidence for the interplay of technology and learner dimensions on learning outcomes. CT sociability enhanced positive social environment while proximity, namely collocated learners, led to higher academic achievement and positive social environment. There was also an interaction between CT sociability and proximity i.e., distributed teams with high sociability had higher positive social environment.

In addition, unique to this study, the interaction between the social context and communication processes and its impact on learning outcomes was examined. Study III

extended the role of task-related and socio-emotional communication processes conceptualized in Study II by theorizing the importance of the equilibrium effect, a balance of task-related and socio-emotional communication activity. This was termed the task-related and socio-emotional activity balance (TSAB) in the paper. The research found that TSAB was better for distributed learners in terms of self-reported learning and academic achievement. As for interaction effects, TSAB enhanced the relationship between CT sociability and positive social environment. TSAB also resulted in distributed learners having higher self-reported learning and academic achievement.

7.1.1 Research Context

The three studies were designed to have different theoretical tilts yet be similar in research context. In other words, while focusing on different aspects of the theoretical framework, the three studies had similar research settings. This would allow the resultant findings to illuminate differences in the theoretical design. These consistencies in research setting can be summarized in terms of the learning environment, the CT employed, and the type of task.

First, in all three empirical studies, it was intended that learners be participants of authentic learning environments. All studies were conducted with undergraduates in higher education in actual courses. Students enrolled in these courses with the intention of passing the course and graduating from University. The projects that students were tasked with amounted to a significant percentage of the passing grade of the course. Authentic learning environments are ideal research settings in which empirical data can be collected as they increase external validity and reduce the pressure of participants to respond to the experimenter's expectations.

Second, all three studies utilized the wiki as the CT of focus. Several wiki software were utilized: Study I employed Mediawiki and Wetpaint, Study II, Mediawiki and Confluence while Study III utilized Co-wiki (based on PmWiki software) and We-Key (based on PmWiki but for use in Facebook). Recalling the levels of wiki systems conceptualized earlier in Table 5.6 (Section 5.7), Mediawiki, Confluence and Co-wiki can be considered level 1 wiki systems

as they contain the same basic set of technological features. These features are web-based access, multiple author editing, and document versioning (allowing past history of the document to be retrieved). Wetpaint and We-Key can be viewed as level 2 wiki systems as they extend the basic functionality of wikis. All three studies therefore used wikis as a baseline for further study and assessment.

The task in an empirical study is a crucial component in research (Fjermestad & Hiltz, 1998; Gladstein, 1984). In all three studies, a similar type of task was planned. Past literature has suggested that there are two main types of tasks, simple versus complex. Simple tasks are well-structured and have a single solution while complex tasks have ill-structured problems and multiple solutions (Cohen, 1994; Morris, 1966). These three tasks in the studies are considered complex tasks. For each of the tasks assigned, there was no single solution and groups were expected to gather, evaluate and synthesize information from a variety of sources. These complex tasks are especially important in learning and collaboration as it determines the amount of interdependency among learners, generates cognitive conflict and resolution, and motivates learners to participate (Cohen, 1994).

By design, the deliverables were similar across the studies. All tasks were group tasks, requiring groups of 3 to 6 students. The task was a project or assignment that related to an aspect of information systems. Groups had a minimum of 2 weeks to complete the task. Study I's task was a group assignment requiring students to produce answers to a set of open-ended questions in an introductory module to computing. In Study II, the deliverable demanded from the student groups was a report on an aspect of ICT in a module that taught about the impact of computers in society. Study III's task was a group report on a set of open-ended questions in a management of information systems module. In essence the task type in these three studies was the same; all three studies employed a complex task.

7.1.2 Overall Findings

The thesis conceptualizes learning outcomes to be dependent on learner and CT characteristics as well as the communication process. In sum, the thesis has examined the learner characteristics of gender, age, instructor support, CT experience and proximity and the CT characteristics of sociability and visibility. Communication process was investigated in terms of task-related and socio-emotional activities. Six dependent variables were investigated in the various studies: self-reported learning, academic achievement, process satisfaction, solution satisfaction, sense of community and positive social environment.

To answer our overarching research question, we first examine the learning outcomes for each study. Although it was intended that all three studies measure the six learning outcomes proposed in the theoretical framework, practically it was not possible. However, three learning outcomes were consistent in all the studies, academic achievement (ACA), self-reported learning (SRL), and positive social environment (PSE). The first two represent the learning performance while the latter is a socio-related outcome. The mean values for each learning outcome for the three studies are depicted in Table 7.1. For academic achievement, the percentage of the average grade was calculated for easy comparison across studies. For the self-reported scales, this was measured on a 7-point scale.

Table 7.1 Mean values of Learning Outcomes across Studies

Average	ACA (%)	SRL[1]	PSE[1]
Study 1	74.67	5.04	5.27
Study 2	67.30	5.08	5.19
Study 3	78.73	5.35	5.02

Note: [1] Likert scale 1 to 7 was used where 7 is the highest value

We note that the values from these studies should not be seen as direct comparisons as they were derived from different research models. Nevertheless, as can be seen from the positive values: ACA>67%, SRL and PSE >5, the use of wikis for team projects led to favorable results. The tutors found that the reports that students produced met their learning objectives as shown by the positive range of the grades given. Students also reported gaining knowledge and skills from using the wiki in the project. Similarly, a positive social environment was felt by students as they completed the project. Although the average value of 5 in a scale of 7 is

not on the extreme positive side, it is closer to the positive side as compared to the negative range. Students did not feel neutral or indifferent toward their learning outcome. This suggests that the wiki is both perceived to and does enhance learning outcomes in groups.

Based on the findings from the three studies, self-reported learning was predominantly affected by the communication process. When it was affected by the inputs, it was when the social context interacted with task-related and socio-emotional communication. Self-reported learning was directly enhanced by task-related activity and socio-emotional activity. In addition, self-reported learning was greater with task-related and socio-emotional activity balance (TSAB) in distributed teams and when there was low CT sociability and TSAB. This suggests that the communication process plays a large role in influencing the perceived learning of team members. However, greater communication, either task or socio-emotional, should not be at the expense of process losses such as information overload, which could lower cognitive knowledge building and understanding.

More support was shown for the hypotheses relating to academic achievement. The social context and communication process all affected academic achievement. For the technology dimension, low CT sociability and public visibility enhanced academic achievement. For the learner dimension, older learners as well as collocated team members had higher academic achievement. As highlighted previously, task communication improved academic achievement but socio-emotional activity did not. Academic achievement was also enhanced with the interaction between learner and CT characteristics. With younger learners, using high CT sociability and public visibility enhanced academic achievement as compared to older learners. In addition, academic achievement was higher for distributed team members with TSAB. These findings have several theoretical and practical implications which will be explored below

As for the learning outcome, positive social environment, considerable support was shown for this socio-related outcome. High CT sociability improved positive social environment. As for

learner characteristics, collocated learners had higher positive social environment. In addition, the communication processes, task-related activity and socio-emotional activity increased positive social environment. Several interaction effects for positive social environment were also supported. For younger learners, using high CT sociability enhanced positive social environment. Additionally, high CT sociability as well as TSAB strengthened the positive social environment of distributed team members.

In addition, post-hoc analysis of the findings in Study III found a strong relationship between positive social environment and academic achievement. This suggests that positive social environment could serve as a mediator between TSAB (as well as other inputs) and academic achievement. This is consistent with some studies that have found that a positive learning climate helps to increase academic performance (Gomez, et al., 2010). There seems to be a direct relationship between the socio-related outcomes and the learning performance of academic achievement. This link can be further investigated.

Next, we examine the impact of the interplay of CT characteristics and learner characteristics on learning outcomes. These characteristics are the social context of any learning activity. Two learner characteristics were constant in the three studies, age and gender. However, Study III did not specifically hypothesize the effect of gender and age; these were actually controls. Studies I and III looked at the direct and interacting effect of age and gender on learning outcomes while Study II examined the effect of the two antecedents on task-related activity and socio-emotional activity.

For gender, the findings for the relationships were mixed. Study I found that gender did not affect self-reported learning or academic achievement while Study III found that males had higher self-reported learning than females while females had higher academic achievement than males. The relationship between gender and positive social environment was non-significant in Study I while it was statistically significant in Study III; males had higher positive social environment than females. On the other hand, one survey in Study II showed

that males had higher socio-emotional activity than females while both genders had similar amounts of task-related activity.

Several reasons account for these inconsistencies. Statistically, it could be because there is a margin of variance in the data that resulted in the varying results. Another reason as indicated in Study II is the effect of group composition especially in technology-mediated environments. The studies had argued for gender effects based on the gender-role socialization and task/relationship orientation arguments. However, we failed to consider the role of gender composition in the group, which has been shown to affect group processes and outcomes (Savicki & Kelley, 2000). This could have led to the inconsistencies in the results. Nevertheless, despite the differences, the findings for gender are not significant in opposing directions. This suggests that gender can affect group processes and learning outcomes. However, the effect of gender is contingent on other mediating and moderating effects which serve to dilute or heighten gender effects. Past research on the influence of gender on learning has also been mixed (Hong, 2002; Jeffrey, 2009; Karuppan, 2001; Phadtare, et al., 2009). This calls for consolidation of the research on gender on learning outcomes through empirical analysis such as the meta-analysis.

Unlike the results for gender, the findings for age were relatively more consistent. Study I revealed that older learners had higher academic achievement but this was not supported in Study III although the sign of the path coefficient was in the anticipated direction. In both studies, the effect of age on positive social environment was non-significant. In Study II, both surveys showed that older learners had higher task-related activity, but learners of all ages had similar levels of socio-emotional activity. These findings lend support to the development view that older learners have wider experiences and deep learning strategies to perform better. It also suggests that learners of all ages are able to use the wiki to socialize and build a conducive social environment.

However, there was one anomaly, younger learners had higher self-reported learning in Study III; this was non-significant in Study I. This possibly suggests the influence of the "digital native" effect where younger learners are increasingly adept at employing technology to learn. At the same time the findings highlight a possible pitfall. Younger learners might consider themselves being able to learn better on these new CTs but in reality they do not possess the skills and experiences to manage and do well on these platforms. Training for these younger learners is required to allow them to practice better collaboration strategies and critical thinking skills. We note that these findings must be accepted with caution as a limitation of the studies is that the age range was small, around 19 to 30 years old.

Next, the CT characteristic, sociability revealed interesting findings. The result for CT sociability was consistent across the two studies which utilized two different wikis from different wiki system levels in terms of positive social environment. Studies I and III showed that high sociability enhanced positive social environment as predicted. Unfortunately, sociability did not affect self-reported learning or academic achievement according to what was hypothesized. In Study I, high sociability led to lower academic achievement but this was non-significant in Study III. No effect for sociability on self-reported learning was found in both studies. The studies have explained that a mitigating factor is information overload. High CT sociability presented learners with more complexity resulting in a lower level of reprocessability and information overload. The cognitive load from sharing too much information in a CT that allows several informal and communication spaces hindered learners from synthesizing their report and performing well. The result of sociability on learning outcomes uncovers an unexpected paradox. High CT sociability improves socio-related outcomes but depresses learning performance. In other words, while high CT sociability builds the social environment, it makes it harder for learners to learn. It could suggest that CT developers need to be cautious in designing level 2 wikis to enhance learning performance. Although CTs with more sociable features can help to generate a better learning climate, they can be potentially distracting to learning. A right mix of plugins to help enhance the

sociability and resultant peer-to-peer interaction as well as helping to manage the complexity of the CT is needed. Towards this end, some research is underway such as the WikiDesignPlatform (Larusson & Alterman, 2009) which aims to improve group collaboration. Still, more theoretical and practical research is needed to develop the new breed of CTs for learning performance as well as socio-related outcomes.

The thesis also predicted the interaction between the learner and technology dimension. Although not all interactions were statistically significant across the studies, the findings suggest the overall importance of the interacting relationship between technology and learner dimensions. These can further illuminate the non-significant findings for the direct effects of the social context on learning outcomes and also provide direction for when such antecedents affect learning outcomes. As suggested by previous models of group behavior (Cohen & Bailey, 1997; Gladstein, 1984), the social context acts on every participant in the group in direct and indirect ways, and this will affect group effectiveness. For instance, there was an interaction between age and sociability in Study I. Younger learners using high CT sociability had higher academic achievement and a positive social environment as compared to older learners. Study III found that the learner characteristic, proximity, interacted with CT sociability. Low CT sociability strengthened the self-reported learning of distributed team members as compared to collocated team members. These findings further suggest that there are areas where sociability can be beneficial for both learning performance and socio-related outcomes.

Another key component explored in this thesis is the role of task-related and socio-emotional communication processes. In Study II, the main effect of communication on outcomes is examined. The study revealed that both task-related and socio-emotional activities individually affect learning outcomes as predicted. To further understand the impact of the communication process, Study III theorized that these two types of communication need to exist in a balance i.e. TSAB, in order to enhance learning outcomes. However, no direct

relationship was found for TSAB and learning outcomes, except for a negative relationship with academic achievement i.e. more task activity enhanced academic achievement rather than equal amounts of the two activities. In Study II, it was found that socio-emotional activity did not enhance academic achievement but task-related activity did. This suggests that task-oriented communication is still more important for enhancing academic achievement as compared to socio-emotional communication. Task communication helps to externalize and articulate the learner's own conceptions. It enables ideas to be generated and discussed which can be refined to produce a good report. On the other hand, socio-emotional communication does not help learners to inter-relate points and contribute to the report. It could be that there is a missing mediator in the relationship between socio-emotional activity and academic achievement.

Nevertheless, the thesis acknowledges the importance of TSAB through its moderating effect. The communication component is in an interacting relationship with the social context, both the learner and technology dimensions. TSAB moderated the relationship between proximity and learning outcomes. It strengthened the self-reported learning and academic achievement of distributed team members more than collocated team members. Moreover, TSAB moderated the relationship between CT sociability and learning outcomes. TSAB with low CT sociability enhanced learner's self-reported learning while TSAB with high CT sociability generated a more positive social environment. These results are in accordance with our predictions and indicate the importance of TSAB for enhancing learning outcomes. It demonstrates the salience of the interacting relationship between the communication process, social context and learning outcomes.

7.2 Revised Theoretical Framework

The overall direction for this thesis was based on the functional perspective as well as elements from the psychodynamic perspective. Adopting the functional theoretical lens, an I-P-O model was designed. The inputs consist of learner and CT characteristics, the processes,

task-related activity and socio-emotional activity, and the output, the learning outcomes including academic achievement, self-reported learning and positive social environment. The thesis predicted that the inputs will affect learning outcomes directly. In addition, the inputs will also affect the communication process. The communication process will subsequently affect the learning outcomes. As for the psychodynamic perspective, socio-emotional activity and socio-related outcome is investigated. The thesis also predicted an interaction between the CT characteristics and learner characteristics in affecting learning outcomes. Another interaction effect was proposed between inputs and processes which can influence learning outcomes.

The three empirical studies did not refute the validity of the theoretical framework. However, the thesis has revealed that certain relationships in the framework can be further refined. First, the findings have revealed that socio-emotional activity did not enhance academic achievement and even lowered it. However, socio-emotional activity enhanced self-reported learning and positive social environment. Second, the findings show evidence for a positive and direct relationship between positive social environment and academic achievement. Past research has suggested that relationship building and cohesion are crucial in allowing teams to coordinate and eventually perform well in the task (Lin, et al., 2008). In the same vein, the thesis proposes a refinement of the theoretical framework in which positive social environment serves both as a final outcome as well as a mediator in affecting academic achievement. We hypothesize that higher positive social environment will enhance academic achievement. This is depicted in Figure 7.1.

This theorizing is very much in the domain of the functional perspective which focuses on performance outcomes. In this day and age, it is still important or even more crucial for CT to be assessed based on objective performance measures. This allows educators, students and system developers to account for the utility of this new breed of CT. This thesis has focused on the wiki as the new wave of CT used for learning groups in pedagogical tasks. Salient

antecedents examined were sociability, visibility, age, gender, wiki experience, instructor support and proximity. This theoretical framework is sufficiently broad enough to be utilized in the context of other CTs used for learning. Future research could examine other antecedents pertinent to the CT of choice with the same theoretical lens.

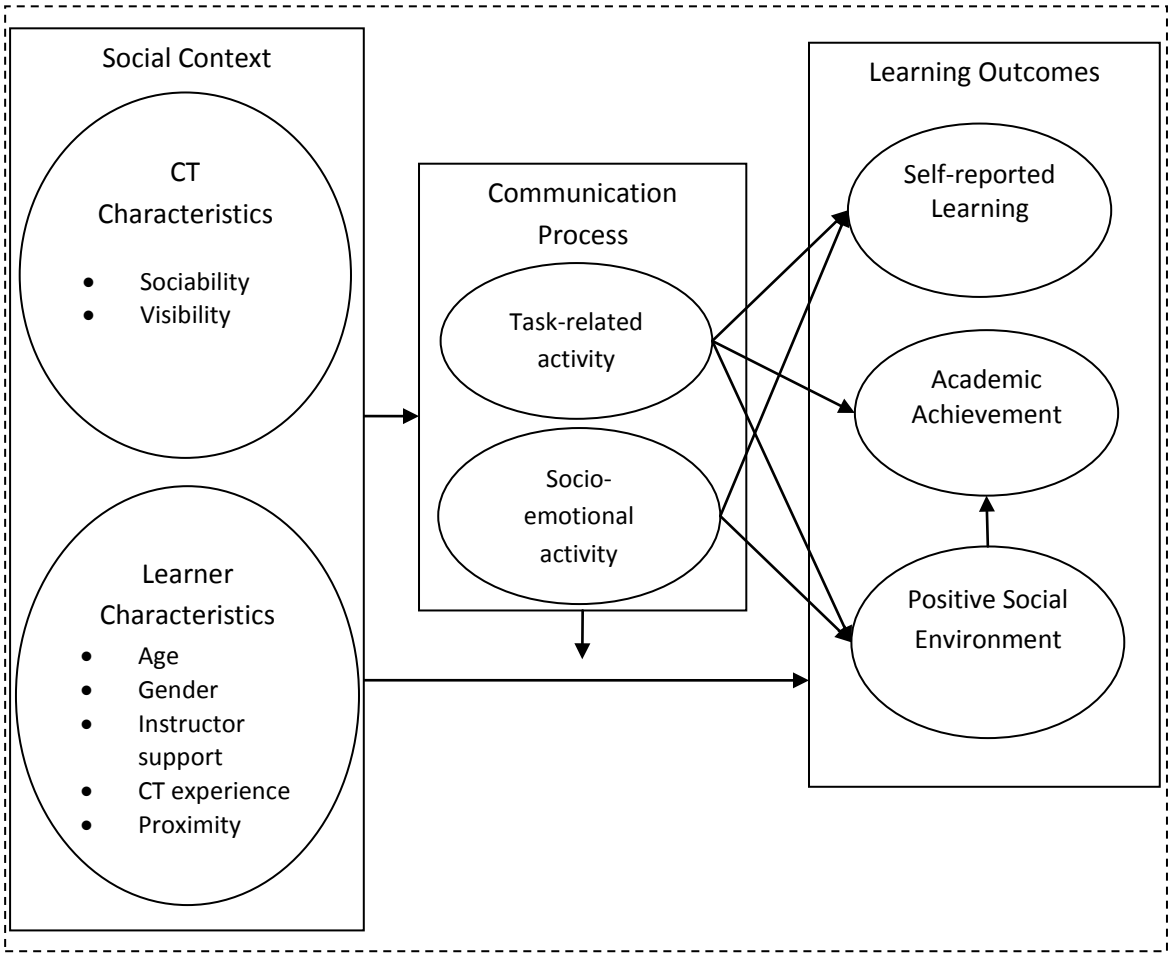


Figure 7.1 Revised Theoretical Framework of CT Effectiveness

Chapter 8: Concluding Remarks

A fresh wave of CTs has cascaded into our world. These web-based CTs may provide a new way of working and collaboration. This thesis examines key issues concerning the wiki, an increasingly popular form of the new breed of CTs. It has been adopted widely in learning groups based in education and in organizations. Unfortunately, empirical research has lagged behind the wiki's ascent in the marketplace. Does the use of CT, primarily the wiki, affect learning outcomes? This research question forms the overarching theme of the thesis. Through the literature review, we have identified several CT characteristics and learner characteristics salient to learning outcomes. This thesis is a pursuit of theoretical factors and relations that demonstrate the effectiveness of CTs in learning groups. Based on several theoretical lenses including the functional and psychodynamic perspectives, a theoretical framework is developed for CT effectiveness (Section 3.1). Guided by the theoretical framework, three empirical studies were performed.

Study I examined the relationship between learner and technology dimensions as well as learning outcomes through a quasi-experiment. Two salient CT characteristics were investigated: sociability and visibility. These were found to be associated with several learning outcomes. Similarly, two learner characteristics were examined: age and gender. Several positive associations were found for the relationship between the learner characteristics and learning outcomes. Besides the direct effect, the study also showed moderating effects of the two dimensions on learning outcomes. Notably, younger learners had higher academic achievement with high CT sociability as compared to older learners.

Study II focused on the communication processes in the learning groups. The role of task-related and socio-emotional communication activities was investigated which has typically been ignored in IS and education research. The study conceptualized that these two communication activities have a direct impact on learning outcomes. In addition, the effect of the learner characteristics, wiki experience, perceived instructor support, age and gender, on

the communication process was examined. Using the survey methodology, two wiki-based CTs were used for the same task by different students. The findings reveal similar results for the two different CTs. In addition to highlighting the importance of the relationship between task-related and socio-emotional activities and learning outcomes, the study puts forth a classification scheme to conceptualize the notion of levels in segregating wiki-based systems, permitting derivation of implications for CT development and instructional use.

Study III seeks for an important aspect concerning the understanding of the social context (CT sociability and proximity) and communication process in affecting learning outcomes. A quasi-experiment was conducted with two different CTs in a team project that spanned Singapore and the United Kingdom. The study's findings show that CT sociability is important for the development of a positive social environment while the salience of proximity is found despite growing occurrences of distribution in global virtual teams. In addition, the study demonstrated the saliency of a balance of task-related and socio-emotional activities in moderating the relationship between the CT sociability and learning outcomes as well as proximity and learning outcomes. The research contributes to extant literature by pinpointing areas where CT sociability and a balance of task and socio-emotional activities can enhance outcomes in distributed teams.

Putting together the theoretical review and the three empirical studies, the thesis has conceived of an important conceptualization in which learning outcomes can be facilitated. The social context and communication activities bring about learning outcomes through direct and interacting ways. It is inadequate to conceive of a single relationship that affects learning outcomes, rather, a multidirectional interaction exists (Terborg, 1981). These relationships as expressed in the revised theoretical framework of CT effectiveness (Section 7.2) provide a middle-level theory that can inform research and practice in the IS, education, organizational psychology and social psychology research fields.

The thesis has also revealed the effectiveness of these new breeds of CTs in learning groups. Empirical findings uncovered several mixed results for many of the hypotheses. This suggests that wiki effectiveness depends on several multifaceted conditions. Nevertheless, in all three studies, learners perceived that using the wiki allowed them to increase their self-reported learning and positive social environment as well as receive positive academic achievement. Therefore, the thesis does not refute the claim that wikis are ineffective.

In the thesis, input factors (CT characteristics and learner characteristics), communication processes (task-related and socio-emotional activities) and their relationships with learning outcomes were explored. Key findings of the thesis include: the need for high CT sociability and public visibility especially for younger learners, the dual importance of task-related and socio-emotional activities, and the paradoxical relationship between CT sociability and learning outcomes.

Lastly, the thesis has shown the importance of examining a broader perspective of learning outcomes. Rather than focusing on learning performance, for instance, academic achievement, alone, the saliency of socio-related outcomes such as positive social environment is established. Such socio-related outcomes are also crucial to academic achievement.

The remainder of this chapter addresses contributions, limitations and future research.

8.1 Contributions

This thesis has performed an empirical investigation of a new breed of CT, the wiki, in learning groups. The research has found that CT affects learning outcomes of students in learning groups. Several CT characteristics, learner characteristics as well as communication processes were identified as salient. The following sections analyze the contributions of the thesis in the areas of research and practice.

8.1.1 Contributions to Research

In this day of rapid technology change and evolution, a new wave of CT has emerged. The wiki is one of the forefronts of the new breeds of CT and the focus of this thesis. Wikis are being adopted rampantly in education and organizations yet without much thought on its effectiveness. This study has foremostly proposed a framework of CT effectiveness. Through three empirical studies it has tested the relationships in the framework. Although mixed results have been found, the thesis shows that wikis can be effective for learning. This is the first contribution of the thesis to research. Theoretical and empirical evidence shows the facilitative effect of wikis in learning groups. Theoretically, a framework of CT effectiveness is developed based on the integration of two theoretical lenses, the functional and psychodynamic perspectives. This consists of learner and CT characteristics, communication processes and learning outcomes. Empirically, it demonstrates that wikis affect learning outcomes such as self-reported learning, academic achievement and positive social environment. In sum, this highlights that wikis are a beneficial form of CT that serves to help learners to collaborate and learn.

Second, the thesis has identified several pertinent factors that serve to enhance the effectiveness of CT. These characteristics belong to two dimensions in the social context, the learner and technology dimension. Five learner characteristics were examined: age, gender, wiki experience, instructor support and proximity while two CT characteristics were investigated: sociability and visibility. From the empirical studies, it is clear that most of the learner characteristics affect the degree to which wikis are effective. In particular, the thesis highlights the role of instructor support and proximity. These inputs have been shown to affect learning outcomes i.e. greater perceived instructor support and closer proximity led to higher learning performance and socio-related outcomes.

Two CT characteristics, sociability and visibility were delineated. These characteristics have not been empirically tested using wikis and the results therefore contribute to the emerging literature of pertinent characteristics for this new breed of CTs. Although some findings were

non-significant, generally, sociability and visibility affected learning outcomes. Moreover, the two characteristics enhanced learning outcomes under certain conditions such as age and task-related and socio-emotional activity balance. In addition, it is possible to conceive of these characteristics in other CTs such as social networks and micro-blogging. For example, the social networking site, Facebook, has added a chat function in addition to the other communication spaces such as the wall, the status update and the message function, which may conceivably enhance the sociability of the application. Another example is the micro-blogging tool, Twitter, which allows either modes of visibility. This highlights the saliency of these two CT characteristics and their contribution to the emerging research literature of CT 2.0.

Another contribution of the thesis is the focus on communication processes. The thesis examined two fundamental aspects of communication, task-related activity and socio-emotional activity. Past studies have typically ignored non-task activities in research. However, socio-emotional activity is especially important in computer-mediated group interaction. As can be seen from the findings, socio-emotional activity played a significant role in affecting the learning outcomes, especially self-reported learning and positive social environment. Since these two activities were first proposed by Bales (1950), the importance of socio-emotional activity has declined over the years. This thesis reinstates the criticality of examining the socio-emotional aspect in group interaction.

In addition, the thesis extends the line of research on these communication processes by conceptualizing the task-related and socio-emotional activity balance (TSAB). We have shown how this balance is critical when learners collaborate using this new breed of CT. In essence, the thesis sheds new theoretical ground by conceptualizing the importance of TSAB which may be pivotal for further empirical research on CTs.

Lastly, drawing from the psychodynamic lens, the thesis adopts a broad-based approach of learning outcomes. Learning outcomes consists not only of learning performance, which has

been typically utilized in past research, but also socio-related outcome. The thesis shows the utility of examining the social environment which is an increasingly relevant measure in this world. Moreover, as revealed in the final study, socio-related outcomes also affect learning performance. Thus, the thesis offers a holistic approach to examining learning outcomes, contributing to research in IS, education, organizational psychology and social psychology research fields

8.1.2 Contributions to Practice

The thesis provides practical implications for three groups of stakeholders: system designers, educators and learners.

8.1.2.1 System designers

Through the process of this thesis, existing CT systems have been used as the baseline software for the research. Many of the wiki engines employed allow the CT to be customized to the research setting. Based on the empirical investigations, we have developed a classification scheme consisting of three levels of wikis for group work in Section 5.7. This classification scheme allows system designers to examine their current software development and pinpoint further areas of development. For instance, designers of existing level one systems can expand their offerings such that levels two and three wiki systems can be catered for. In turn, this would offer potential users more choices and a higher incentive to adopt the particular wiki engine. With more users using the wiki software and even paying for certain services, the wiki's reputation and business viability will grow.

In particular, the thesis has highlighted two essential aspects of the new breed of CTs, sociability and visibility. We believe these two characteristics can enhance the capabilities of CTs for collaboration and learning. Based on the research findings, higher sociability is associated with the positive social environment of learners. However, the research also found that CT sociability did not contribute to self-reported learning or academic achievement. It seems that CT sociability needs to be designed in a way that does not distract from the task.

The research observed that the complexity of systems with high sociability might have affected the learning performance. This suggests that in designing sociable CT, system designers still need to pay attention to usability and ensure a seamless system that allows multiple avenues for informal and formal communication.

As for visibility, the findings reveal that public visibility contributes to higher academic achievement and solution satisfaction (Section 4.4). This reinforces the importance of having public visibility in CT. However, the privacy concerns of many users are still a major concern and may explain the lack of significance for self-reported learning, process satisfaction and positive social environment. On one level, this suggests that system designers should provide both modes of visibility for user to have the option of choosing the most suitable one for them. We note that the learning outcomes that focus more on the process of collaboration and not the final output are affected by public visibility. Some explanation for this is found in group development literature where during the forming, storming and norming stages, this is a delicate time period where members come to understand their roles and negotiate about the task (Tuckman, 1965). This is the thrashing out period, and most individuals would prefer the private mode of visibility as it is akin to airing their dirty laundry in private rather than in public. This then suggests the importance of designing both access modes with a temporal button. For instance, CTs could be programmed to automatically change access mode from private to public when the project is about to be completed.

The thesis also highlights the importance of communication processes in teams. We believe that CTs can be designed to facilitate both task-related activity and socio-emotional activity. As previously highlighted, CT tends to encourage task-related activity. As positive socio-emotional activity is also important to learning outcomes, CT should cater for this communication too. Moreover, both these communication activities has been shown to be helpful if they exist in a balance. System designers can therefore design features to encourage equal levels of such communication. For example, an indicator plug-in could be developed in

CTs that can scan through text to give a gauge of the team's level of task-related and socio-emotional activities.

8.1.2.2 Educators

The thesis offers several practical suggestions for educators. Two general areas are surmised: selection of CT for higher learning outcomes and the preparation of scaffolds for learners.

In selecting CT, the research provides several guidelines which should enhance learning outcomes. An important premise as stated in Chapter 2 is that a group task is designed. Educators should aim to use CT in a group project that involves collaboration and results in a collective output from members of the group. The research has found that two learner characteristics seem especially pertinent in the selection of CT for higher learning outcomes: age and proximity. The educator should consider the age as well as the proximity of learners. For age, younger learners seem to do better with CT that has high sociability and public visibility while older learners thrive on the opposite, performing better with low sociability and private visibility. Thus it seems that in teaching a younger class, educators should adopt CT with high sociability and use the public mode of visibility. For an older class, the CT employed should have low sociability and a private mode of visibility.

As for proximity, the research has revealed that when learners are far apart from each other, CT with high sociability improves learning outcomes, especially positive social environment. On the other hand, for learners who are near each other, low CT sociability seems to help in their learning performance. This suggests that educators in distance education courses or teaching distributed teams should adopt CT with high sociability while those in blended education courses where students are collocated should adopt CT with low sociability. We draw a flowchart for the recommended selection of CT in Figure 8.1.

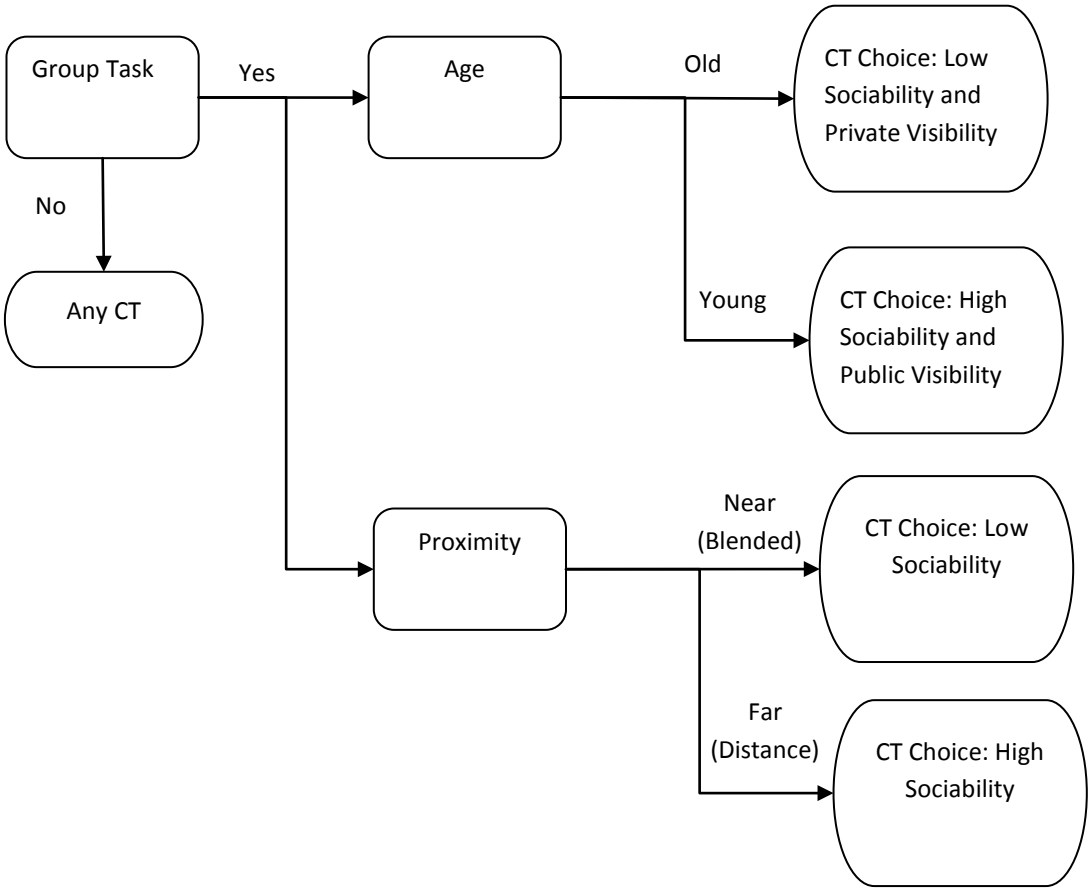


Figure 8.1 Flowchart for the Educator's Selection of CT

The next area which pertains to educators is the preparation of scaffolds for learners. By scaffolds, we refer to the kinds of instructional support for learners. From the study, we find that instructor support is critical for learner's communication process and outcomes. As we encountered in the study, the type of instructor support can vary in any course. Especially for this new breed of CT, instructor support in the form of training must be provided for learners before they can embark on the group task with the CT. We have discovered that three types of instruction should be provided: technical training, task instruction and group maintenance skills training. Technical training pertains to the usability of the CT, how one can use the features of the CT. Task instruction is the explanation and clarification of the project task at hand. Group maintenance skills training consists of collaboration techniques, communication skills and other social etiquette that is necessary for the expressive needs of the learning group using the CT. The latter is sometimes taken for granted and its neglect may lead to disastrous consequences. Therefore, educators should especially prepare scaffolds in group maintenance

skills for their students. This includes encouraging students to communicate task-related and also socio-emotional activities, teaching editing etiquette and suggesting collaboration strategies.

8.1.2.3 Learners

Several practical takeaways apply to students in learning groups. When learning groups are formed, much of the time, the instructor would expect the group to exert a degree of independence. This is very much the case in Higher education, which sees project work as a training ground for students to work in teams. These groups can be likened to self-managing work teams in organizations where there is no constant external supervision. For learners in these groups, the thesis has revealed several important skills. We proffer three necessary skills: deep thinking, managing information complexity and open communication.

First, deep thinking skills, which is essentially the deep approach to learning, involves the critical analysis of information and concepts. Younger learners as compared to older learners seem to be susceptible to a lack of deep thinking skills. Thus, it is especially important for learners, especially younger learners to acquire these skills. We recommend learners to adopt a critical approach to information and not absorb content at face-value; they should question and clarify what the text means or represents.

Second, as more and more information is shared in the group, learners need to know how to manage the accumulated content before information overload occurs. As discussed in the thesis, information overload was a pitfall for many learners. Therefore, managing information complexity is crucial for learners to achieve learning outcomes. We acknowledge that there is no easy solution for managing information complexity. One strategy is the conveyance of information i.e., providing summaries of the discussion. This should be done not only at the end of the project but at every step of the way, during the whole process of collaboration to provide clarity and understanding.

Third, open communication has been highlighted as an essential skill in facilitating learning outcomes. Open communication takes into account both task-related and socio-emotional activities. Basically, learners should communication their ideas and thoughts. This should be done with tact and consideration to other members in the team. In this way, team members are valued and stay cooperative; and the task is discussed and completed. Finally, the end result will have a high likelihood of achieving learning outcomes.

8.2 Limitations and Future Research

As with all research, this study suffers from several limitations. This section synthesizes the limitations of the thesis. First, the quantitative research methodology was employed, specifically two quasi-experiments and a survey. While we have previously discussed the limitations of each research method, we believe that our investigation could have provided a deeper understanding of the processes and perceptions of learners. The quantitative research methods employed did not provide rich details of many interaction processes leaving the researcher to provide interpretations based on theories and other research. In this regard, we could have made use of the case study approach as well as content analysis to shed more light on the interaction of learners.

Second, the empirical studies made the assumption that all students made use of the wiki to collaborate. Certain students may have relied on their groupmates to edit the wiki and not use the wiki themselves. However, in each study, we checked that all learners had edited the wiki at least once, through the history function provided in the wiki. Still, the studies did not account for the usage intensity or that all features of the wikis was used. Another issue was that face-to-face meetings as well as other forms of CT could have been used in addition to the wiki. Although the use of the wiki was compulsory, it was difficult to control student's actual usage in the blended learning environment. A possible remedy is that future studies employ laboratory experiments to ensure that participants only make use of the wiki and all its features to collaborate. Nevertheless, post-test questionnaires asked for students' media

usage frequency for wikis and other media. These revealed no significant effects of other media usage on learning outcomes and on average students responded that they used the wiki once a week to several times a week.

Third, this research aimed to find out if wikis affect learning outcomes. To a certain extent, the thesis has provided empirical support for wiki effectiveness. However, the contribution of this thesis could be made more significant if the thesis examined the improvement of learning outcomes with wikis through the use of a control group, i.e., traditional face-to-face groupwork. Future research could also compare between wikis and other CTs such as Microsoft Word (Dishaw, Eierman, Iversen, & Philip, 2011). This would further help to illuminate the differences in traditional face-to-face, blended and distance learning. In addition, the research has examined learning outcomes from the cognitive and affect domain. However, other domains such as those in the psychomotor area e.g. efficiency and response magnitude, could be examined.

Several learner characteristics and CT characteristics were examined in this study. These characteristics are not exhaustive although we argued that the ones chosen were particularly salient for this new breed of CT. For learner characteristics, we examined age, gender, instructor support, wiki experience and proximity. However, the findings revealed mixed support for these learner characteristics. Notably, wiki experience was not found to affect any communication process. Also, the study did not examine a possible three-way interaction between variables such as between proximity, age and learning outcomes. This could be examined in future research. Other learner characteristics may be more salient to investigate wiki effectiveness in learning groups. Two such characteristics were discovered in this study, group composition and configuration. Gender composition and subgroups in the team have been shown to affect group interaction and outcomes. This is fertile area for future research.

As for CT characteristics, the thesis has investigated two salient ones, sociability and visibility. An issue that arose in the paper was that the systems designed to represent high and

low sociability were affected by loading time and usage complexity. This suggests that the usability of wikis needs to be further examined. This is a fundamental aspect of any new CT, that it should allow users to have ease of use. As seen by many adoption studies, perceived ease of use and perceived usefulness affects the intention to use a system (Davis, 1989). The thesis also proposed that CT characteristics would directly affect learning outcomes. However, these factors may be mediated by communication processes; this is another area of research. Three other CT characteristics were conceptualized: communication support, connectivity and information structure. These can be further examined in wikis or in other breeds of CTs. Moreover, the paper has described three levels of wiki systems. This research has analyzed level 1 and 2 wiki systems. Other research can analyze the effects of level 3 systems.

Similarly, for group processes, other mediating processes can be considered such as participation, exchange of information and cooperation (Tyran & Shepherd, 2001). Another limitation of the existing communication process was that task-related activity and socio-emotional activity were self-reported measures. The original construct employed content analysis but this was typically employed in experimental groups with short durations i.e., 1 to 2 hours. The large data set as well as the lengthy duration made this infeasible. Research has shown that self-reports are as accurate as observer coding for observable, desirable and frequently occurring situations (Gosling, et al., 1998). Our research did not focus on negative socio-emotional behavior, which also tends to be under-reported in the literature. Thus, we modified the measure as consistent with several studies (Green & Taber, 1980; McGrath, 1991; Walther, et al., 1994).

As we studied the phenomenon of using wikis for group projects, two pedagogical issues arose. First, the training that is required for students to use the wikis. We realized that training for the wiki was not just in terms of technical know-how, but also in collaboration strategies and group dynamics. It seems that groupwork is not instinctive to many students and requires

certain collaboration skills. A second issue was the design of the task and how learners could benefit from it. While the studies all examined the group task as the be-all and end-all, other literature has suggested that individual reflections alongside the group task can also improve student's learning. For instance, Wang (2010) found that in addition to collaboration on the CT, progress reports, where students were required to write weekly, were instrumental for students' learning. The weekly progress report allowed students to manage their collaborative efforts and reflect on their learning. These suggest that the kind of training provided and the individual learning reports could be complementary pedagogical strategies to improve learning using the wiki. These can be further examined.

Next, a limitation of the study is that the findings can only generalize to the context in which it was examined. We planned to widen the scope of the thesis by conceptualizing general learning groups that used wikis. In this regard, despite our findings based on learners in tertiary education, we believe that theoretically these findings should apply to learners in organizations and in K-12 education (Primary and Secondary Schools). Nevertheless, we advise readers to use these findings with caution due to the possible uniqueness of the team, task and other research settings.

Lastly, this thesis employed the functional and psychodynamic lens to explore group behavior. However, all studies examined time-limited groups which had a strict deadline for the task. Group development research has highlighted the temporal nature of group activities such as brainstorming in the initial stage and convergence in the later stage. The temporal aspect of the group could be further illuminated to provide for richer explanations of group processes and outcomes. In essence this would also allow for a tri-partite integration of theoretical perspectives and contribute further to extant research.

In conclusion, the exploration of how collaborating with CT fosters learning and discovery is a noteworthy mission and this thesis has illuminated factors from the current social context and communication process that affect learning outcomes. Nevertheless, group collaboration

with CTs remains a fertile ground for investigation, and much research is still needed to learn how to increase its effectiveness.

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Appendixes

A1. Group Assignment Question

1. Select an e-commerce company, except amazon.com and dell.com, that adopts the pure play model. Explain the company's

- Value propositions
- Revenue model
- Ability to leverage the Internet's capabilities

2. Discuss the viability of online delivery services. For instance dabao.com.sg, an online food delivery service, recently closed shop after one and a half years.

3. Provide an example of an information system that you have used before. Describe the fundamental components of the system and how it has helped you as a user or the organization that implemented the system.

A2. Survey Items

	Self-reported Learning (Alavi, 1994)
SRL1	I increased my skills in critical thinking
SRL2	I increased in ability to integrate facts
SRL3	I increased in ability to critically analyze issues
SRL4	I was more confident in expressing ideas
SRL5	I learned to value other points of views
SRL6	I learned to interrelate important topics and ideas
SRL7	I increased in understanding of basic concepts
SRL8	I learned factual material
SRL9	I learned to identify central issues
	Solution Satisfaction (Green, & Taber, 1980)
SSA1	I was satisfied with the quality of my team's solution
SSA2	The final solution reflects my inputs
SSA3	I feel committed to the team solution
SSA4	I am confident that the team solution is correct
SSA5	I feel personally responsible for the correctness of the team solution
	Process Satisfaction (Green, & Taber, 1980)
PSA1	My team's problem-solving process was efficient
PSA2	My team's problem-solving process was coordinated
PSA3	My team's problem-solving process was fair
PSA4	My team's problem-solving process was understandable
PSA5	My team's problem-solving process was satisfying
	Positive Social Environment (Kreijns, Kirschner, Jochems, & van Buuren, 2007)
PSE1	Teammates felt free to criticize ideas, statements, and/or opinions of others
PSE2	We reached a good understanding on how we had to function
PSE3	Teammates ensured that we kept in touch with each other
PSE4	We worked hard on the team assignment
PSE5	I maintained contact with all other teammates
PSE6	Teammates gave personal information on themselves
PSE7	The team conducted open and lively conversations and/or discussions
PSE8	Teammates took the initiative to get in touch with others
PSE9	Teammates spontaneously started conversations with others
Manipulation Check	

	Sociability (Kreijns, Kirschner, Jochems, & van Buuren, 2007)
SOC1	This system enables me to easily contact my team mates
SOC2	This system enables me to get a good impression of my team mates
SOC3	This system allows spontaneous informal conversations
SOC4	This system enables us to develop into a well performing team
SOC5	This system enables me to develop good work relationships with my team mates
SOC6	This system enables me to identify myself with the team
SOC7	I feel comfortable with this system
SOC8	This system allows for non task-related conversations
SOC9	This system enables me to make close friendships with my team mates
	Visibility (Self-developed)
VIS	This system is visible to other Internet users as members of the public can view my work on the system

B1. List of Constructs and Measures

Constructs	Measures	Mean (Wiki 1)	Mean (Wiki 2)	Sources
Instructor Support (ISU)				
InstSup1	I was aware of the instructor's online presence	3.51	3.88	(Garrison et al., 2000; Kanuka et al., 2007)
InstSup2	The instructor was available to me	3.93	4.23	
InstSup3	The instructor was available to my group members	4.02	4.36	
InstSup4	The instructor facilitated my group's activity in the online medium	3.58	3.76	
InstSup5	Overall, I had a great deal of interaction with my instructor	3.42	3.63	
Task-related Activity (TRA)				
TRA1	I made suggestions about the task	5.20	5.73	(Bales, 1950; Green & Taber, 1980)
TRA2	I gave information about the problem	5.38	5.56	
TRA3	I asked for information from others	4.98	5.38	
Socio-emotional Activity (SEA)				
SEA3	Others expressed a positive opinion about your behavior	5.13	5.12	(Bales, 1950; Green & Taber, 1980)
SEA4	I was unfriendly (reversed)	5.69	5.95	
SEA5	I was frustrated (reversed)	5.93	6.07	
Self-reported learning (SRL)				
SRL4	I was more confident in expressing ideas	4.87	5.12	(Alavi, 1994)
SRL6	I learned to interrelate important topics and ideas	5.09	5.20	
SRL7	I increased in understanding of basic concepts	4.91	5.27	
SRL9	I learned to identify central issues	5.04	5.14	
Process Satisfaction (PSA)				
PSA3	My team's problem-solving process was fair	5.11	5.33	(Green & Taber, 1980)
PSA4	My team's problem-solving process was understandable	5.00	5.30	
PSA5	My team's problem-solving process was satisfying	5.18	5.33	
Positve Social Environment (PSE)				
PSE1	Teammates felt free to criticize ideas, statements, and/or opinions of others	5.16	5.57	(Kreijns et al., 2007)
PSE2	Teammates ensured that we kept in touch with each other	5.00	5.47	
PSE3	We worked hard on the team assignment	5.13	5.76	

PSE4	I maintained contact with all other teammates	4.98	5.58	
PSE5	Teammates gave personal information on themselves	4.53	5.22	
PSE6	The team conducted open and lively conversations and/or discussions	4.89	5.45	
PSE7	Teammates took the initiative to get in touch with others	4.91	5.40	
PSE8	Teammates spontaneously started conversations with others	4.73	5.42	
PSE9	Teammates asked others how the work was going	4.80	5.48	
Sense of Community (SCO)				
SCO1	I feel that students in this course care about each other	3.93	4.65	(Rovai, 2002)
SCO2	I feel connected to others in this course	4.09	4.63	
SCO3	I feel that this course is like a family	3.60	4.17	

C1. CT Screencasts

Screencasts were made to familiarize students to the 2 systems. Part 1 describes the basic usage of the CT while Part 2 describes further tips on how students can collaborate on their project using the CT.

Part 1: Introduction to Co-wiki, how to edit and create pages
http://www.youtube.com/watch?v=MY6j4MMhsAo

Part 2: Tips on collaborative authorship on Co-wiki

http://www.screencast-o-matic.com/watch/cQVef0npE

Part 1: Introduction to We-Key, how to edit and create pages
http://www.screencast-o-matic.com/watch/cQV2fdnHL

Part 2: Tips on collaborative authorship on We-Key
http://www.screencast-o-matic.com/watch/cQV2hLnH8

C2. Virtual Team Task

You are an employee of a newly-formed transport and delivery company, Global Transport Pte Ltd. Senior management has assigned you and your teammates to a virtual team to carry out the following task. The task has three components.

1) Prepare a summary for senior management on the impact of globalization on the use of information systems in business. In this summary you should discuss various issues especially relating to the transport and delivery sector.

2) Senior management is considering the implementation of a decision support system in the company. What are the characteristics of a decision support system? In your team, select three characteristics and elaborate on how they will benefit the company.

3) Information systems facilitate many decisions businesses have to make in day to day work. In the transport sector, transportation and delivery businesses use online software tools to map

out their transportation routes to select the most efficient route. MapQuest (www.mapquest.com) is one such system. It can calculate the distance between two points and provide itemized driving directions to any location. However, this service is limited to the North American Region.

Your first assignment is to deliver computer hardware from the School of Computing, National University of Singapore, Singapore, to either

a) the International Convention Centre in Birmingham, England OR

b) the Shanghai International Convention Center (You have the option of choosing either location a or b, but not both.)

Write a description of the kinds of decisions your team will have to make to deliver the equipment and the kind of information that you would need for those decisions. Suggest how information systems could supply this information. You should use the system model to illustrate the inputs, processes, and outputs that will be required for the information system. Lastly, plan the best route to transport the equipment between the two locations i.e. Singapore and location a) or b).

C3. Means of Variables

a. Means of CT Sociability and Proximity

SOC	PRX		SRL	ACA	PSE
Low	Distributed	Mean	5.24	11.32	4.62
		N	41.00	41.00	41.00
		Std. Deviation	0.95	1.90	1.24
	Collocated	Mean	5.53	12.20	5.23
		N	40.00	40.00	40.00
		Std. Deviation	0.76	1.14	1.10
	Total	Mean	5.38	11.75	4.92
		N	81.00	81.00	81.00
		Std. Deviation	0.87	1.62	1.20
High	Distributed	Mean	5.29	11.40	5.04
		N	34.00	34.00	34.00
		Std. Deviation	0.74	1.42	0.80
	Collocated	Mean	5.34	12.29	5.21
		N	40.00	40.00	40.00
		Std. Deviation	0.76	1.24	1.03
	Total	Mean	5.32	11.88	5.14
		N	74.00	74.00	74.00
		Std. Deviation	0.75	1.39	0.93
Total	Distributed	Mean	5.26	11.35	4.81
		N	75.00	75.00	75.00
		Std. Deviation	0.86	1.69	1.07
	Collocated	Mean	5.44	12.24	5.22
		N	80.00	80.00	80.00
		Std. Deviation	0.76	1.18	1.06
	Total	Mean	5.35	11.81	5.02
		N	155.00	155.00	155.00
		Std. Deviation	0.81	1.51	1.08

b. Means of CT Sociability and TSAB

Note: A median-split was performed for DFB to calculate the means.

SOC	TSAB		SRL	ACA	PSE
Low	More balance	Mean	5.40	11.71	4.84
		N	48.00	48.00	48.00
		Std. Deviation	0.70	1.34	1.18
	Less balance	Mean	5.36	11.82	5.04
		N	33.00	33.00	33.00
		Std. Deviation	1.08	1.98	1.24
	Total	Mean	5.38	11.75	4.92
		N	81.00	81.00	81.00
		Std. Deviation	0.87	1.62	1.20
High	More balance	Mean	5.32	11.96	5.36
		N	42.00	42.00	42.00
		Std. Deviation	0.78	1.35	0.91
	Less balance	Mean	5.31	11.77	4.84
		N	32.00	32.00	32.00
		Std. Deviation	0.72	1.46	0.88
	Total	Mean	5.32	11.88	5.14
		N	74.00	74.00	74.00
		Std. Deviation	0.75	1.39	0.93
Total	More balance	Mean	5.36	11.83	5.08
		N	90.00	90.00	90.00
		Std. Deviation	0.73	1.34	1.09
	Less balance	Mean	5.34	11.79	4.94
		N	65.00	65.00	65.00
		Std. Deviation	0.91	1.73	1.07
	Total	Mean	5.35	11.81	5.02
		N	155.00	155.00	155.00
		Std. Deviation	0.81	1.51	1.08

c. Means of Proximity and TSAB

PRX	TSAB		SRL	ACA	PSE
Distributed	More balance	Mean	5.42	11.53	4.92
		N	40.00	40.00	40.00
		Std. Deviation	0.71	1.45	1.17
	Less balance	Mean	5.09	11.16	4.70
		N	35.00	35.00	35.00
		Std. Deviation	0.98	1.93	0.95
	Total	Mean	5.26	11.35	4.81
		N	75.00	75.00	75.00
		Std. Deviation	0.86	1.69	1.07
Collocated	More balance	Mean	5.32	12.07	5.22
		N	50.00	50.00	50.00
		Std. Deviation	0.76	1.21	1.01
	Less balance	Mean	5.63	12.53	5.23
		N	30.00	30.00	30.00
		Std. Deviation	0.73	1.10	1.15
	Total	Mean	5.44	12.24	5.22
		N	80.00	80.00	80.00
		Std. Deviation	0.76	1.18	1.06
Total	More balance	Mean	5.36	11.83	5.08
		N	90.00	90.00	90.00
		Std. Deviation	0.73	1.34	1.09
	Less balance	Mean	5.34	11.79	4.94
		N	65.00	65.00	65.00
		Std. Deviation	0.91	1.73	1.07
	Total	Mean	5.35	11.81	5.02
		N	155.00	155.00	155.00
		Std. Deviation	0.81	1.51	1.08