Effects of Socio-Cognitive Conflicts on Group Cognition and Group Performance

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Dedication

This dissertation is dedicated to my parents, my siblings (Lu Pien and San Shian), my fiancée (Bee Lian), my brother-in-law (Seow Chong), and my sister-in-law (Mui Luang) for their endless support and encouragement.

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ABSTRACT

Socio-cognitive conflict is a mechanism that drives cognitive development/learning in collaborative learning. Such conflicts occur when individuals have different perspectives on the same problem. To adequately solve problems, groups face the challenge of integrating different perspectives, which when successful can result in an increase in shared knowledge (i.e., knowledge convergence), an intermediate process-related collaborative learning outcome. Knowledge convergence plays an important role in explaining the quality of group performance, an ultimate collaborative learning outcome.

However, students do not always learn from one another in groups, with studies revealing variability in collaborative learning outcomes. Among other factors, their communication can be unproductive or productive. This mixed evidence could be because: (1) interactions have not been analyzed using instruments developed with theoretical and empirical underpinnings within a socio-cognitive conflict paradigm to measure a comprehensive range of socio-cognitive processes; and (2) it is insufficient to assign group tasks without providing any scaffolding.

My study acknowledges these issues and uses a randomized experimental design that aims to: (1) Test out a script that strives to scaffold interactions to generate collaborative socio-cognitive processes. To analyze interactions, my study uses an instrument capable of identifying a comprehensive range of socio-cognitive processes; and (2) Examine the effect of socio-cognitive processes on knowledge convergence and consequently on the quality of group performance.

Findings suggest that the script offers a promising way to facilitate the type of productive communication to make group-work beneficial. It generated interactions with collaborative socio-cognitive processes. Additionally, the frequency of collaborative socio-cognitive processes is positively related to the increase in shared knowledge in terms of the number of similar elements and statements members had in common after dyads' interactions. Also, the increase in the number of similar elements is positively related to the quality of dyads' performance, whereas there is no corresponding effect for statements.

Implications for designing collaborative learning activities include requiring the duration of students' interactions to be long enough to have sufficient collaborative socio-cognitive processes so as to have substantial knowledge convergence and higher quality of group performance. Future studies include addressing issues regarding measurement accuracy in analyzing chat-logs and knowledge convergence.

CHAPTER 1

INTRODUCTION

1.1 Overview

Imagine for a moment two classmates sending instant messages to each other about the school's service learning project from the comfort of their homes.

Paul: What do you think of visiting an old folks home for our service-learning project?

Roy: Hmm... We did that last year. I remembered we helped clean the home.

Paul: Oh yes. Perhaps we could do something different then?

Roy: We could still visit a home, but we do something different this time at the home.

Paul: Say more...

Roy: Perhaps, we could buy some gifts?

Paul: It is costly to buy gifts. Shall we put up a performance for them instead?

Roy: Performance?

Paul: Perhaps we could sing or do a skit to entertain them?

Roy: Sounds great. Let us run through this idea with our class tomorrow.

Do such scenes involving discussion between two adolescents via texting instant messages – be it study-related or simply casual chat - sound real and familiar? With the proliferation of instant messaging technologies (e.g., Skype, gmail chat, mobile phone

chat applications such as SMS, and WhatsApp messenger) and social networking sites (e.g., Facebook), adolescents frequently communicate with their friends using instant messages (Lenhart, Madden, and Hitlin, 2005).

Trends in these technologies have led educators to facilitate and enhance collaborative learning in lessons through the use of media that enable both asynchronous and synchronous communication among students and teachers. Collaborative learning is widely recognized as being more effective than most other pedagogical approaches (Johnson and Johnson, 2009). It is based on the idea that learners examine and discuss learning materials in a group without direct or immediate intervention from the teacher (Cohen, 1994). This approach of learning is critical, especially as we look toward making education effective for the 21st century (e.g., Ben-Jacob, Levin, and Ben-Jacob, 2000). Owing to advances in technology, collaborative learning does not have to be limited to just the classroom now. Educators can and should leverage this effective approach even when students are outside the classroom.

However, just because collaborative learning is effective on average does not mean it will always work well or could not work better. By bringing together students with different perspectives/ideas on the same problem, group members face contradictions to their perspectives, thereby experiencing socio-cognitive conflicts. The emergence of differences in opinion does not guarantee good learning outcomes but is important primarily because these differences may generate communication among members (Blaye and Gilly as cited in Dillenbourg, Baker, Blaye, and O'Malley, 1996). The communication can be productive or unproductive and thus can be an important factor that affects the quality of collaborative learning.

On the one hand, if the communication is productive, students can learn from one another by reconciling their differences through integrating and synthesizing different perspectives and by engaging in negotiation toward the development of group cognition (i.e., mutually constructed/shared knowledge that collaborating learners have) (Fischer and Mandl, 2005). If done well, this may result in knowledge convergence (i.e., an increase in group cognition (Jeong and Chi, 2007)). Viewed as a crucial intermediate process-related outcome of collaborative learning, knowledge convergence plays an important role in explaining the quality of group performance (Lim and Klein, 2006), an ultimate outcome of collaborative learning. It facilitates coordinated action, ensuring that all group members are solving the same problem and thus exploiting the cognitive capabilities of all members (Orasanu as cited in Klimoski and Mohammed, 1994). On the other hand, if the communication is unproductive, students might not learn from one another in groups and might continue to face unresolved differing opinions without gaining any insights from their differences.

The use of scripts offers a promising way to improve the effectiveness of group-work by helping students learn from one another through making communication productive. The use of a social script that specifies and sequences interactions has shown success in structuring interactions (e.g., Weinberger, Stegmann, and Fischer, 2010). Scripts can therefore be used to create interactions that help group members share and integrate their differing ideas, thereby facilitating members to learn from one another in groups. Beyond this, experimental studies, where a group was given a script (versus a control group without a script), might help illuminate how these interactions may occur and how they can in turn affect collaborative learning outcomes. Little is known about

the specific discourse patterns of how learners interact in groups that can affect the quality of group processes that in turn affect collaborative learning outcomes (Van den Bossche, Gijselaers, Segers, Woltjer, and Kirschner, 2011). Scripts can potentially be used to generate interactions containing specific functional conversational moves (e.g., clarifying, qualifying) that represent socio-cognitive processes inherent in interactions, and these can be collaborative or non-collaborative socio-cognitive processes. Although a comparison of collaborative learning outcomes that arise from scripted and naturalistic interactions might lead to valuable insights regarding the optimal functioning of groups, this has not been accomplished in prior studies because the instruments used to analyze interactions in previous studies were not developed to measure a comprehensive range of socio-cognitive processes.

1.2 Objectives of Dissertation

Within the larger goal of leveraging socio-cognitive conflicts and instant messaging technologies to develop collaborative learning activities, my study uses a randomized experimental design that aims to: (1) Test out a script that is intended to generate interactions with collaborative socio-cognitive processes. To analyze interactions, this design uses a coding scheme that shows evidence of reliability and validity, and is capable of identifying a comprehensive range of functional conversational moves that represent the observable form of socio-cognitive processes inherent in interactions; (2) Examine the effect of socio-cognitive processes on knowledge convergence and consequently on the quality of group performance.

1.3 Background and Context

Having presented the broad research themes that drive this study, this section presents an extended justification to derive these research themes into a set of specific research questions. In doing so, it also provides explicit rationales of why certain research design features were used in this study. This section first presents the conceptual model of collaborative learning and its outcomes, namely group cognition, knowledge convergence, and group performance. This is followed by the presentation of the use of scripts in collaborative learning.

1.3.1 Conceptual Model of Collaborative Learning and its Outcomes

The conceptual model of collaborative learning and its outcomes shown in Figure 1.1 underlies this study. The different research strands of this conceptual model are elaborated in this section to provide an extended justification of this study.

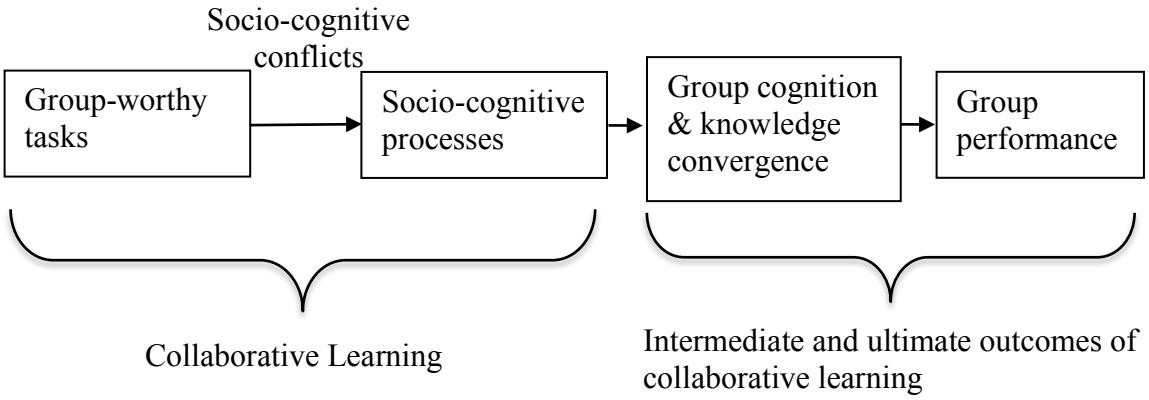

Figure 1.1. Conceptual model of collaborative learning and its outcomes (group cognition, knowledge convergence, and group performance) underlying this study.

Group-worthy Tasks

The following design elements are necessary for group tasks, without which learners can easily complete tasks by working individually and might refuse to devote

time/effort to build group consensus, thereby negating the usefulness of group-work (Lotan, 2003):

1) are open-ended and require complex problem-solving;
2) allow learners to have multiple entry points to the task and multiple chances to exhibit intellectual competence;
3) involve discipline-based, intellectually important content;
4) require interdependency among members and individual accountability; and
5) include clear evaluation criteria of group product.

Hence, in my study, the group tasks will have these features.

Socio-cognitive Conflicts

According to the Piagetian equilibration model of socio-cognitive conflict, learning is a process of personal construction of knowledge mediated by cognitive conflicts of social origin, where there is a perceived contradiction between the learner's existing understanding and what the learner experiences through interactions with others (Webb and Palincsar, 1996). Such contradictions are traditionally induced through learning tasks that are designed within the socio-cognitive conflict paradigm (e.g., Limon, 2001; Mugny and Doise, 1978). This paradigm is based on the idea that, by pairing students with different initial conceptions or by presenting collaborating peers with information that contradicts their conceptions, they will experience cognitive conflict. This contradiction and the disequilibrating effect it has on learners provide an opportunity for learners to reexamine their ideas/beliefs and might motivate them to resolve the cognitive conflict (King, 2002). As learners explain and defend their views to group members, those

conflicts can be reconciled, thus promoting cognitive development and learning (Skoumios, 2009).

Students do not always learn productively from one another in groups. The emergence of differences in opinion does not guarantee good learning outcomes but is important primarily because these differences may generate communication among members (Blaye and Gilly as cited in Dillenbourg, Baker, Blaye, and O'Malley, 1996), which can be productive or unproductive. As explained earlier, this communication can be productive (i.e., results in the development of group cognition) or unproductive (i.e., results in continued unresolved differing opinions without gaining any insights from differences in opinions). Variability in collaborative learning outcomes found in research studies related to socio-cognitive conflicts have provided evidence that mere diversity in perspectives is insufficient and that the relationship between socio-cognitive conflicts and cognitive development is not fully understood. On the one hand, some researchers have found that learners showed more cognitive growth when faced with socio-cognitive conflicts (e.g., Johnson, Johnson, Pierson, and Lyons, 1985). On the other hand, others have found conflicting/inconsistent results (e.g., Druyan, 2001). For example, Tudge (1989) found that cognitive regression was at least as likely as development in his study of 5-7 years old dyads' collaboration to solve a mathematical problem within a socio-cognitive conflict paradigm. Additionally, other researchers have qualified the effect of socio-cognitive conflict in group learning. Learners have to go beyond mere disagreement to benefit from cognitive conflict (Bearison, Magzamen, and Filardo, 1986; Damon and Killen, 1982). For example, Nastasi, Clements, and Battista (1990) argued that resolution, rather than occurrence, of socio-cognitive conflict is a catalyst for

cognitive development. More recently, some researchers provided empirical evidence that learners have to engage in argumentation for socio-cognitive conflicts to be effective (Asterhan and Schwarz, 2009).

Socio-cognitive Processes

Although researchers have recognized the need to examine the quality of group processes via analyzing learners' interactions to better understand the effect of socio-cognitive conflict on cognitive development and learning (e.g., Gunawardena, Lowe, and Anderson, 1997), little is known about the specific discourse patterns or functional conversational moves of how learners interact in their groups that can provide insights into the optimal functioning of groups in collaborative learning. According to Cheng (2011), the functional conversational moves that learners make in response to socio-cognitive conflicts represent the observable form of socio-cognitive processes inherent in interactions, and these can be collaborative (e.g., eliciting, clarifying, qualifying) or non-collaborative (e.g., asserting, threatening, voting). For example, in the chat-log presented at the beginning of this chapter, Paul tried to elicit ideas and details from Roy by sending a text message that read "*Say more*". This text message by Paul is considered a collaborative functional conversational move, namely "eliciting".

Thus far, a variety of methods (e.g., conversational analysis and using coding schemes) have been developed to analyze interactions. However, the instruments (e.g., coding schemes) used in existing studies to analyze interactions have not been developed theoretically and empirically to measure a comprehensive range of socio-cognitive processes via the functional conversational moves that learners make in their response to

socio-cognitive conflicts. Hence, existing findings obtained using those coding schemes to analyze interactions might have reliability and validity issues.

Nevertheless, analyzing interactions by measuring socio-cognitive processes via the functional conversational moves that learners make in response to socio-cognitive conflicts can be one approach that potentially provides insights into the effect of socio-cognitive conflicts on knowledge convergence and consequently on the quality of group performance. Interactions with high frequency of collaborative socio-cognitive processes that result in groups with synthesized and shared knowledge of strategies/solutions to address their tasks can lead to better group performance (e.g., higher quality of group products). By contrast, interactions with low frequency of collaborative socio-cognitive processes can result in continued differing knowledge of strategies/solutions that do not lead to better group performance.

Group Cognition and Knowledge Convergence

Given that the emergence of differences in opinion is less important than the communication it generates to integrate contrasting perspectives to form a shared understanding of the problem and solution, a key outcome of resolving socio-cognitive conflicts is the advancement in group cognition (i.e., knowledge convergence). The growing interest in group cognition can be recognized by a multitude of similar terms such as common ground, team mental models, shared understanding, and collective mind (Akkerman et al., 2007). For instance, some researchers in learning sciences refer to the concept of knowledge convergence (e.g., Weinberger, Stegmann, and Fischer, 2007), whereas some in the organizational sciences (e.g., Klimoski and Mohammed, 1994) refer to the equivalent concept of shared mental models. All these terms refer in some ways to

the structures of collective meaning that emerge in and coordinate the activities of a group (Akkerman et al., 2007). In my study, I will define:

1) group cognition as group members' shared, organized understanding and mental representation of knowledge about key elements of the group's relevant environment (Klimoski and Mohammed, 1994); and
2) knowledge convergence as an increase in group cognition (Jeong and Chi, 2007).

The various types of group cognition include shared representation of concepts, tasks, equipment, working relationships, and situations (Mohammed and Dumville, 2001). For example, shared representation of tasks describes and organizes knowledge about how the tasks are accomplished in terms of procedures, task strategies, likely contingencies/problems, environmental constraints, and task component relationships (Cannon-Bowers, Salas and Converse, 1993). The corresponding knowledge convergence is referred to as task convergence.

Although there is a growing recognition of the importance of understanding how group cognitions develop (Mohammed and Dumville, 2001; Akkerman et al., 2007), limited studies on collaborative learning have examined discourse patterns that underlie knowledge convergence (Van den Bossche, Gijselaers, Segers, Woltjer, and Kirschner, 2011). Research on collaborative learning has focused on how interaction affects knowledge construction (Barron as cited in Van den Bossche et al., 2011), rather than knowledge convergence, and on determining the structural conditions (e.g., group compositions and size, nature of tasks) that lead to better learning outcomes (Webb and Palincsar, 1996; Van den Bossch, Gijselaers, Segers, and Kirschner, 2006).

Among the few studies that did explore discourse patterns and knowledge convergence, Van den Bossche et al. (2011) used a questionnaire to find out learners' perception of their group's interaction style and found that constructive conflict (i.e., dealing with differences in interpretation among team members by arguments and clarifications) related positively to the development of knowledge convergence. By contrast, co-construction (i.e., a mutual process of building meaning by refining, building on, or modifying others' statements) did not relate to the development of knowledge convergence. In another study, Fischer and Mandl (2005) used qualitative single case studies and reported that learners with high knowledge convergence transactively built on one another's contributions. My study will also contribute to understanding how group cognition develops through the examination of the effect of collaborative socio-cognitive processes (via analyses of interactions) on group cognition.

Group Performance

Beyond the intermediate process-related group outcomes, according to Hackman (1990), there are three primary types of ultimate group outcomes: (1) group performance (quality and quantity); (2) group longevity; and (3) members' affective reactions. Although each type is important, the focus in my study is on the quality of group performance or, more specifically, the quality of group products. The definition of quality is dependent on and defined according to the unique context of each group-work. In general, research studies have found positive effects of the increase in group cognition or shared mental models (i.e., knowledge convergence) on the quality of group performance (e.g., Mathieu et al., 2005; Lim and Klein, 2006).

1.3.2 Scripts in Collaborative Learning

Since the emergence of differences in opinion is important primarily to generate communication among members, the use of scripts offers a promising way to ensure that the communication is productive. Not only can the use of scripts generate socio-cognitive conflicts, it also can scaffold learners' interactions to help them embrace these conflicts to lead to collaborative socio-cognitive processes within the conceptual model of collaborative learning and its outcomes shown in Figure 1.1. More specifically, the use of scripts can help members interact using high frequency of collaborative socio-cognitive processes to help members reconcile their differences through integrating and synthesizing different perspectives.

However, despite recent successes in the use of scripts to create socio-cognitive conflicts and to scaffold and analyze learners' interactions, the analyses of scripted interactions usually pertain to argumentative aspects (e.g., using coding schemes based on Toulmin's (1958) framework of everyday argument). The lack of use of coding schemes with strong theoretical and empirical underpinnings in socio-cognitive conflicts to measure a comprehensive range of socio-cognitive processes remains an issue. The various types of scripts include epistemic and social. Epistemic scripts specify and sequence the learning task to facilitate knowledge construction activities, whereas social scripts specify and sequence learners' interactions to facilitate collaborative learning (Weinberger, Ertl, Fischer, and Mandl, 2005). For example, social scripts based on Toulmin's (1958) framework of everyday argument require students' interactions to include argumentation elements (e.g., claim (students' position), grounds (reasons), qualification (limitations of claim)).

Nevertheless, scripts have shown success in scaffolding interactions even if the ensuing interactions were not analyzed using coding schemes developed for understanding the inherent socio-cognitive process via the functional conversation moves that learners make in their responses to socio-cognitive conflicts. Such scripts were typically tested under experimental conditions, with an experimental group given a script to scaffold their responses to either group members' responses in group tasks or questions given in individual tasks. By contrast, those in a control group were allowed to respond freely. In these studies, interactions were usually analyzed using coding schemes that focus on argumentation elements. Scripted learners acquired more domain-specific knowledge and knowledge of engaging in constructive argumentation than did unscripted learners (Weinberger, Stegmann, and Fischer, 2010).

Given the success of scripts in scaffolding interactions, a script can potentially be used to generate interactions containing collaborative socio-cognitive processes. Thus, my study will test out a social script (called collaborative socio-cognitive process script) on an experimental group to examine its effect on socio-cognitive processes. It is developed specifically for my study to induce collaborative socio-cognitive processes to examine the effects of these processes on knowledge convergence. To analyze the ensuing interactions, I will use Cheng's (2011) coding scheme that shows evidence of reliability and validity to identify the functional conversational moves that learners make in response to socio-cognitive conflicts.

1.4 Summary

Research studies reveal variability in collaborative learning outcomes, suggesting that mere diversity in perspectives is insufficient. Group-work will only be beneficial if

differing perspectives leads to further negotiation by argument and clarification toward mutually shared cognitions. The use of scripts is a promising way to facilitate the type of productive communication to make group-work beneficial. Beyond this, the use of scripts to facilitate interaction processes provides an opportunity to learn about interaction processes within groups. Although it is critical to examine the quality of group processes through students' interactions to understand the effect of socio-cognitive conflict on collaborative learning outcomes, little is known about the interaction processes and their effects on collaborative learning outcomes, since the instruments used to analyze interactions in previous studies have not been developed to measure a comprehensive range of socio-cognitive processes. Also, despite successes in the use of scripts to create socio-cognitive conflicts and to scaffold and analyze students' interactions, the analyses of scripted interactions usually pertain to argumentative aspects, rather than a comprehensive range of socio-cognitive processes.

Taking all these together, one approach to gain insight into leveraging socio-cognitive conflict more effectively is to test out a script that can facilitate the type of productive communication to make group-work beneficial. That is, the extent in which interaction processes are affected by a script (with versus without) can be examined.

Beyond this, the approach provides the opportunity to use instruments with empirical and theoretical underpinnings to investigate the relationship between collaborative interaction processes and the extent to which learners experiencing socio-cognitive conflicts will advance in their group cognition and have knowledge convergence. That is, the extent in which task convergence is affected by collaborative interaction processes can be examined. Additionally, the relationship between knowledge

convergence and group performance can be investigated by examining the extent in which group performances are affected by task convergence. I posit that interactions containing higher frequency of collaborative socio-cognitive processes can help learners engage in a constructive argumentation process to understand and integrate group members' perspectives. This will in turn resolve their socio-cognitive conflicts, develop group cognition, and lead to higher quality of group performance.

1.5 Structure of Dissertation

I present the literature review of this study in Chapter 2. I begin the chapter with a discussion of the theoretical orientations underpinning this study, namely the constructivist view of learning through conflict and controversy mediated by socio-cognitive conflicts and processes. In this chapter, I also discuss the use of scripts in collaborative learning, as well as present various methods of analyzing online interactions, where I elaborate the technique of quantitative content analysis. I conclude Chapter 2 with an articulation of group cognition and knowledge convergence, where I describe various types of group cognition and discuss key methods of measuring group cognition.

In Chapter 3, I present the specific research questions that define my study. I also present the research design, which includes the data set, description of the experimental conditions, details of the task and procedure, measures and instruments, and the data analytic plan.

In Chapter 4, I present the results of my data analyses, which include validation results of the reliability of the instrument used in analyzing interactions, data inspection,

check on effectiveness of random assignment, descriptive statistics, and the empirical evidence that addresses each research question.

Finally, in Chapter 5, I discuss the results of my data analyses, situating the findings within the teaching and learning community. I conclude my dissertation with a discussion of potential validity threats and implications for instructional practice. In this chapter, where appropriate, I also made recommendations for future research studies.

CHAPTER 2

LITERATURE REVIEW

This study draws on scholarship from a variety of interrelated fields to examine the effect of a script on socio-cognitive processes, as well as the effect of socio-cognitive processes on knowledge convergence and consequently on the quality of group performance. This examination is aided through the help of a coding scheme that shows evidence of reliability and validity to measure a comprehensive range of socio-cognitive processes that are inherent in the ways people respond to socio-cognitive conflicts. Toward this end, in the sections that follow, I summarize relevant and key scholarly literature in the areas of: (1) the theoretical orientations of this study that include constructivist view of learning as well as socio-cognitive conflicts as mediator of group processes; (2) group process via online interactions and methods of analyzing online interactions; (3) scripts in collaborative learning; and (4) group cognition and knowledge convergence. Where appropriate, my literature review also illuminates certain research design features and research methods decisions used in this study.

2.1 Theoretical Orientation

I draw the theoretical orientation of my study from the constructivist view of learning with socio-cognitive conflicts as mediator of group processes. This orientation guides the scaffolding and analysis of online interactions through the use of a coding scheme that measures a comprehensive range of socio-cognitive processes. In essence,

the literature review of this theoretical orientation reveals conflicting findings on the effects of socio-cognitive conflicts on collaborative learning outcomes, with one key reason of these mixed effects being likely in how group members respond to socio-cognitive conflicts via their interaction processes during group-work.

2.1.1 Constructivist View of Learning

Constructivism holds that knowledge results from individuals' interpretations of their experiences in particular contexts. These experiences refer not only to direct individual experiences, but also to learning that occurs through social interactions (Webb and Palincsar, 1996). Collaborative learning stems from the constructivist view of learning, where learners are grouped and activities are designed to allow learners to interact and learn collaboratively from one another during the learning process. In particular, when group tasks in collaborative learning activities have group-worthy elements, collaborative learning is more effective than individual learning with regard to fostering both domain-specific (e.g., trigonometry identities in Mathematics) and domain-general knowledge (e.g., argumentative knowledge) (Johnson and Johnson, 1992). In group-worthy tasks, collaborative learners depend on their group members to a larger degree when working on open-ended tasks that require complex problem-solving (Lotan, 2003; Cohen, 1994).

With regards to both domain-specific and domain-general knowledge, the advantages of collaborative over individual learning are based on the idea that learners can harness their group members as resources, where members contribute new knowledge and ideas during group discussions (Weinberger, Stegmann, and Fischer, 2010). These knowledge and ideas might eventually be shared among the group

members, and this sharing of knowledge and ideas allows individual learners to obtain multiple perspectives on the complex tasks at hand (Weinberger, Stegmann, Fischer, and Mandl, 2007). More specifically for domain-general knowledge, collaborative learners can mutually engage in productive interactions beyond sharing and benefiting from group members' knowledge and ideas.

This mutual engagement in productive interactions can "foster multi-perspective, application-related, transferable as well as argumentative knowledge" (Weinberger, Stegmann, and Fischer, 2010, p. 507). For example, Scheuer, Mclaren, Harrell, and Weinberger (2011) found that collaborative learning in computer-mediated environments has a positive effect on fostering argumentation skills, where learners engaged in more critical and objective argumentation to broaden and deepen their discussions. Nevertheless, it should be noted that such advantages of collaborative learning only apply with regards to group-worthy tasks. Individual learning seems to be better than collaborative learning when the tasks are not group-worthy, such as recalling concepts and facts (Kirschner, Pass, and Kirschner, 2009; Weinberger, Stegmann, and Fischer, 2010).

In part due to this widely accepted constructivist view of the learner where cognitive development is an outcome of social processes, interest in group processes has been growing (Webb and Palincsar, 1996). Several group processes that promote learning and cognitive development have been suggested and investigated by researchers. These processes include conflict and controversy, co-construction of ideas, giving and receiving help, and social-emotional processes (Webb and Palincsar, 1996). For example, in the

conflict and controversy[1] group process, according to Webb and Palincsar (1996), both Johnson and Johnson (1979) and Brown and Palincsar (1989) argued that, by creating uncertainties about the correctness of their beliefs, overt conflict encourages individuals to seek information, explain, and justify their differing perspectives. All these help individuals understand differing perspectives, and thereby learn.

2.1.2 Socio-cognitive Conflicts as Mediator of Group Processes

Of similar importance are the theories or mechanisms that have been proposed to explain how these group processes give rise to individual cognitive processes. Mechanisms have been proposed to shed light on how learners jointly construct knowledge and how interactions with others shape learners' understanding during these group processes.

The Piagetian equilibration model of socio-cognitive conflict is one of the leading theoretical perspectives suggested to be the mechanism that drives cognitive development and learning (Webb and Palincsar, 1996). According to the socio-cognitive conflict perspective, learning is a process of personal construction of knowledge mediated by cognitive conflicts of social origin, where there is a perceived contradiction between the learner's existing understanding and what the learner experiences through interactions with others (Webb and Palincsar, 1996; Doise and Mugny as cited in Skoumios, 2009). In many research studies and teaching strategies, such contradictions are traditionally induced through learning tasks that are designed within the socio-cognitive conflict paradigm (e.g., Limon, 2001; Mugny and Doise, 1978). This paradigm is based on the

[1] There have been variations in the results of research studies on conflict and controversy. Some studies found that conflict does not necessarily promote learning or cognitive development (e.g., Lindow, Wilkinson, and Peterson (as cited in Webb and Palincsar, 1996)), while others have found complex relationships (e.g., inverted U-shaped curvilinear) between conflict and cognitive gains (e.g., Bearison, Magzamen, and Filardo, 1986).

idea that, by pairing students with different initial conceptions or by presenting collaborating peers with information that contradicts their intuitive conceptions, they will experience cognitive conflict. This contradiction and the disequilibrating effect it has on learners provide an opportunity for learners to reexamine their ideas/beliefs. Such an opportunity might motivate them to resolve the cognitive conflict (King, 2002). As learners explain and defend their views to their group members, those conflicts can be reconciled, thus promoting cognitive development and learning (Skoumios, 2009). For example, in many research studies, socio-cognitive conflicts have been induced through engaging learners in dialectical argumentation (a type of socio-cognitive conflict paradigm), where argumentation activities may be encouraged in ways that include elicitation procedures, argumentative scripts, and pairing peers with conflicting opinions (e.g., Asterhan and Schwarz, 2009). Engagement in dialectical argumentation was found to predict gains in conceptual learning.

Research studies on socio-cognitive conflict generally follow two main approaches (Druyan, 2001; Sacco and Bucciarelli, 2008), which focus either on interactions between:

(1) peers with different perspectives. In the interactions of the first type, the learner engages in the process of negotiations that encourage one to verify one's own perspective with perspectives from other individuals with comparable status. Such interactions are believed to have the potential to promote cognitive dissonances within the individual and are effective in promoting cognitive restructuring (Bearison, Magzamen, and Filardo, 1986); or

(2) individuals of different status (e.g., a teacher versus a child, an expert versus a layman). In contrast to interactions of the first type, knowledge is imparted in a

one way linear manner, as one learner is the authority and the source of knowledge, which must be conveyed to the partner. This process involves internalization of the social interaction. However, as there is no joint cognitive restructuring, interaction of this type has a low potential for conflict, thereby providing less opportunities for cognitive development (Piaget, as cited in Webb and Palincsar, 1996). Theoretically, this process is based on Vygotsky's concept of the zone of proximal development (Vygotsky, 1978). Vygotsky believed that solving problems in collaboration with more knowledgeable peers or adults provides the learner the opportunity to advance one's cognitive ability.

My dissertation study focuses on the first.

Regardless of the approach, studies have provided mixed evidence of the role of socio-cognitive conflict in facilitating cognitive development among learners in a group context[2]. On the one hand, researchers have found positive effects of socio-cognitive conflicts on cognitive development and learning. For example, Bell, Grossen, and Ferret-Clermont (as cited in Webb and Palincsar, 1996) measured children's performance on conservation tasks and found that children showed more cognitive growth when they worked with peers, as compared to working individually. However, this relative degree of cognitive growth was only observed when these children were also actively engaged in solving the problem in the conservation tasks, and was not observed when the children simply passively watched their peers working on the problem. Similarly, in another study, Johnson, Johnson, Pierson, and Lyons (1985) found that students who were encouraged to challenge others' thinking to generate cognitive conflict performed better

[2] There have also been mixed theoretical and empirical evidence for Piaget's claim that peer interactions provided greater opportunities for learning than adult-child interactions (Webb and Palincsar, 1996).

on academic achievement and perspective taking measures than students who were encouraged to avoid disagreement.

On the other hand, other researchers have found conflicting or inconsistent results. For example, Tudge (1989) paired learners with different conceptual understanding of concepts involving a beam balance problem and found that learners whose thinking level was initially either the same or more advanced than their partners regressed in their thinking after experiencing socio-cognitive conflicts. Only learners who had a lower level of thinking showed cognitive development from the socio-cognitive conflicts. In another study that had a similar experimental set-up as Tudge's (1989), Druyan (2001) found varying effect of socio-cognitive conflict on cognitive development across learners from different grade levels. Specifically, Druyan (2001) found that socio-cognitive conflict had a positive effect on 5th graders' thinking, no effect on 3rd graders, and a negative effect on preschoolers.

Qualifications made by some researchers on the effect of socio-cognitive conflict in group learning could reconcile these conflicting findings. The occurrence of socio-cognitive conflict and having mere disagreements is not sufficient for learners to benefit. Students have to go beyond mere disagreement to benefit from cognitive conflict (Bearison, Magzamen, and Filardo, 1986; Damon and Killen, 1982). Nastasi, Clements, and Battista (1990) argued that the resolution, rather than the occurrence of socio-cognitive conflict, is a catalyst for cognitive development. Both the number of socio-cognitive conflicts and their manner of resolution are important aspects of effective knowledge acquisition. More recently, some researchers provided empirical evidence that

learners have to engage in argumentation for socio-cognitive conflicts to be effective (Asterhan and Schwarz, 2009).

2.2 Group Processes via Online Interactions

Given this varied evidence, researchers have recognized the need to examine the quality of group processes to better understand the effect of socio-cognitive conflict on cognitive development and learning (e.g., Asterhan and Schwarz, 2009). One effective approach to examine the quality of group processes is to analyze learners' interactions (Gunawardena, Lowe, and Anderson, 1997). Specifically, through analyzing learners' interactions, researchers can understand how learners are responding to socio-cognitive conflicts in group processes, and consequently this allows researchers to gain deeper insight into the complexities of the effect of socio-cognitive conflicts on cognitive development and learning (e.g., Psaltis, and Duveen, 2007; Asterhan, and Schwarz, 2009). Such a strategy in turn could inform the design of collaborative learning environment and activities to make them more effective in aiding learners' cognitive development and learning.

In general, the review of various methods of analyzing online interactions in this section found that quantitative content analysis appears to be one of the most effective methods in allowing researchers to examine the quality of group processes via interactions. However, existing coding schemes used in such analyses had coding categories that were not consistent among various coding schemes. Therefore, they were inadequate on their own to comprehensively cover all aspects of socio-cognitive processes, which in turn might lead to reliability and validity issues. The socio-cognitive conflict style coding scheme developed for this dissertation study is an exception.

2.2.1 Methods of Analyzing Online Interactions

For online environments (e.g., discussion forums) where interactions come in the convenient form of electronically archived transcripts, many researchers examine artifacts of the online interactions (e.g., the learners' messages) to investigate how learning is taking place (e.g., Celentin, 2007). Unlike tests, which Dennen (2008) argued can be used to measure learning only to indicate whether a learner knows certain things but not how those things were learned, such artifacts can provide what Henri (1992) called a "gold mine of information concerning the psycho-social dynamics at work among students, the learning strategies adopted, and the acquisition of knowledge and skills" (p. 118).

In recent years, the proliferation of various forms of computer-mediated communication in education has augmented the techniques available for data collection and analysis of online interactions that supply a wealth of data in the form of electronically archived transcripts. Methods and instruments, which led to richer information from online interactions, have been developed (Fahy, 2001). Early research was mainly restricted to gathering quantitative data about participation levels through participation measures (Henri, 1992). However, such data were insufficient to evaluate the quality of the interactions (Meyer, 2004). Later, content analysis was adopted as a technique to investigate the psycho-social dynamics of groups, the learning strategies adopted, and the acquisition of knowledge and skills (Henri, 1992). This technique was later extended from simple description to inferential hypothesis testing to gain further insights into such psycho-social dynamics. For example, Ahern, Peck, and Laycock (1992) combined content analysis with random assignments of participants to groups and

controlled manipulation of variables. This approach was advanced by other researchers (e.g., Craig, Gholson, Ventura, and Graesser, 2000) who drew convincing conclusions concerning experimental/quasi-experimental conditions.

According to Dennen (2008) as well as Dennen and Paulus (2005), the more commonly used quantitative and qualitative methods that researchers have developed to analyze online interactions include:

(1) quantitative content analysis. According to Berelson (as cited in Rourke, Anderson, Garrison, and Archer, 2001), quantitative content analysis is "a research technique for the objective, systematic, quantitative description of the manifest content of communication" (p. 9), and can be used to help researchers examine a wide variety of constructs. Many content analysis coding instruments, which consist of various categories and their corresponding indicators to allow researchers to code transcripts of interactions, have been developed to analyze various constructs in online interactions (e.g., Anderson, Rourke, Garrison and Archer, 2001; Gunawardena, Lowe, and Anderson, 1997; Henri, 1992; Meyer, 2004);

(2) structural analysis. Structural analysis examines the structure of the discussion to look at the relationship between posts and/or participants, and usually examines an entire thread of discussion (e.g., Hewitt, 2005). According to Dennen (2008), various forms of structural analysis include social network analysis, which examines the relationships between particular dialogue participants, and focuses on issues of centrality and prestige. The shortcoming of using such analysis is that structure alone only indicates activity, without any inherent implications for

quality or learning (Dennen, 2008). Nevertheless, as pointed out by Dennon (2008), such analysis could potentially help compliment other forms of analysis (e.g., content analysis) to provide a fuller picture of certain constructs such as how knowledge construction occurs in a computer-mediated class setting;

(3) microethnography. Microethnography examines both the discussion and the contextual surroundings often using extensive data collection techniques such as surveys, interviews, and field notes to provide a context-sensitive and holistic deep discussion of what took place within the discussion and what it might mean (e.g., Antonijevic, 2008); and

(4) dialogue analysis[3]. Dialogue analysis examines the conversations using linguistic approach and is highly interpretative. It includes conversation analysis, and discourse analysis (e.g., Zheng, Young, Wagner, and Brewer, 2009).

While several methods have been developed to analyze interactions (Dennen, 2008), quantitative content analysis (henceforth called content analysis), or more generally, coding schemes derived from established frameworks (e.g., the framework of everyday argument developed by Toulmin (1958)), appear to be most commonly used to gain insight of the quality of the group learning processes in socio-cognitive conflicts paradigms (e.g., Psaltis and Duveen, 2007). Unlike other methods, content analysis coding schemes allow researchers to investigate the psycho-social dynamics of groups (Henri, 1992), of which the quality of group processes (and more specifically socio-cognitive conflict styles or processes) is one type.

[3] According to Dennen (2008), microethnography and dialogue analysis are much less common in practice. Dennen (2008) cautioned that both microethnography and dialogue analysis should not be confused with the case study approach (Stake, 1995), which is very common and typically macro-level but tends not to be able to provide a sufficiently deep analysis of the discussion.

By contrast, structural analysis, which examines the relationship between participants' online postings in discussion threads and/or participants, would not be useful to gain insights in such group processes. While dialogue analysis could potentially examine such psycho-social dynamics, this method is highly interpretative (Dennen, 2008) and context dependent, where analysis results might be difficult to compare across different studies. Thus, depending on the specific research questions the researcher is investigating, dialogue analysis might not be as appropriate as content analysis, in which objectivity can be tested using inter-rater reliability indices, and where content analysis coding can be carried out across different studies using a common coding scheme to potentially allow for better comparison of results. As for microethnography, it is a broad method of which content analysis could possibly be one of its sub-methods. It provides a context-sensitive and holistic examination of interactions and the contextual surroundings through extensive data collection techniques such as surveys, interviews, and field notes (Dennen, 2008).

2.2.2 Issues Pertaining to Quantitative Content Analysis

Despite the existence of numerous content analysis coding schemes, there exist three key issues that resulted in the coding categories not being consistent among various coding schemes. This inconsistency makes each coding scheme inadequate on its own to comprehensively cover all aspects of socio-cognitive processes.

First, in some studies, the development of the coding schemes was context dependent, and thus might only be applicable in those researchers' contexts and transcripts. The coding schemes were not derived based on theoretical orientations (or prior research), but were based on the researchers' contexts and transcripts, where themes

of specific conversation moves emerged from the transcripts of learners' interaction. For example, Psaltis and Duveen (2007) examined conversations of conservers and non-conservers by using a coding scheme derived from emergent themes of their transcripts. The coding scheme consisted of eighteen conversational moves that were unique to their context and learning tasks that the learners were participating in. These included rebuttals of inequality/equality in which there was an explicit disagreement with inequality/equality of liquids, as well as disclaimers of inequality/equality in which there was a softened disagreement with the inequality/equality of liquids. Similarly, Asterhan and Schwarz (2009) also examined their entire transcripts for themes and developed their initial coding scheme based on the themes. They then refined their coding scheme by having two raters code and discuss their results until the raters reach a certain level of agreement with a satisfactory number of stable and distinctive coding categories of conversational moves. Their final coding scheme included both argumentative moves (claims, request for claims, simple agreements, supports, challenges, rebuttals, simple oppositions and concessions), as well as non-argumentative moves (elaborations, requests for information, and information providing).

As each coding scheme was developed based on different contexts and transcripts, the coding categories in each coding scheme might not provide a complete and valid picture of how learners respond in socio-cognitive conflicts paradigms. Although there might be similarities among different coding schemes (e.g., some overlapping coding categories) developed based on different contexts and transcripts, different coding schemes could have different unique coding categories. Each coding scheme might only pertain to that particular context and transcripts that the researchers were studying. As

such, the content validity might be compromised, and these coding schemes might not fully represent all possible conversational moves of learners when faced with socio-cognitive conflicts.

Second, in other studies, the coding schemes were developed to broadly examine the structures of the conversation (i.e., macro-level), rather than specific conversational moves (i.e., micro-level), to provide a broad overview of the quality of the interaction. For example, Skoumios (2009) used a coding scheme developed by Clark and Sampson (2008), which was originally based mainly on Toulmin's (1958) argumentation framework. Clark and Sampson (2008) defined the quality of argumentation from level 0 to 5, where each level differs on whether there are evidence of claims, counterclaims, grounds and rebuttals. Although this provided insight on the quality of argumentation as a whole, it did not provide specific conversational moves that learners made (i.e., how learners responded to socio-cognitive conflicts), and hence was not meant to provide insight in the group process. In another example, Nastasi and Clements's (1992) study of social cognitive behaviors and higher order thinking used a coding scheme to broadly examine the structures of an online interaction. Their coding categories included social dominance, social negotiation, and cognitively-based resolution.

Third, in some studies, the coding schemes tended to be focused heavily on collaborative or argumentative moves. These coding schemes either provided no or just one to two coding categories for specific non-collaborative moves, such as how learners avoided or compromised when faced with socio-cognitive conflicts (e.g., Skoumios, 2009). For example, in a study involving computer supported collaborative learning, Weinberger and Fischer (2006) developed their coding scheme containing micro-level

categories of argumentative knowledge construction based on the framework of everyday argument developed by Toulmin (1958). Their coding scheme included argumentative moves that consisted of "simple claim", "qualified claim", "grounded claim", and "grounded and qualified claim". As for the non-argumentative moves, the coding scheme did not contain any specific moves, except to describe non-argumentative moves as "questions, coordinating moves, and meta-statements on argumentation" (Weinberger and Fischer, 2006, p. 45). In other examples of studies involving online interactions with socio-cognitive aspects, several other researchers (e.g., Paulus and Phipps, 2008) adopted or modified Gunawardena, Lowe, Anderson's (1997) model of social construction. The coding categories of Gunawardena, Lowe, Anderson's (1997) model included "state new information", "elaborate or provide further explanation", "ask for opinion", "support with evidence", "ask questions to clarify", "identify areas of agreement", and "compare new synthesis against evidence". By focusing on collaborative or argumentative moves, these studies tended to only examine conversational moves that learners used to embrace conflicts. They tended to simply code specific moves on how learners embraced conflicts with much fewer coding categories on non-collaborative or non-argumentative aspects. As such, using coding schemes in those studies would provide a less comprehensive picture of the various ways in which learners responded to such conflicts. A more comprehensive and balanced picture would include examining specific moves that embrace, as well as specific moves that avoid.

In sum, the coding categories were not consistent among various coding schemes, and this resulted in each coding scheme being inadequate on its own to comprehensively cover all aspects of socio-cognitive processes. On the one hand, there were some coding

categories that were similar across various coding schemes. For instance, the ideas of "claim" (or assertion), "rebuttal", and "agreement" appear to be common categories across most, if not all of these coding schemes. On the other hand, there were coding categories that were not universally present in the various coding schemes. In some cases, a few categories were common and present in some coding schemes, but were absent in others. For instance, the ideas of grounded claim (i.e., there is prevision of grounds that warrant the claim), as well as qualified claim (i.e., there is limitation to the validity of the claim), were present in some coding schemes, but not in others. In other cases, certain categories were unique in some coding schemes, and were absent in others. For instance, the ideas of "elaboration" and "request for information" were among the categories of Asterhan and Schwarz's (2009) coding scheme, but were absent in others. In all cases, there were much fewer categories that were indicative of the learners not embracing the socio-cognitive conflicts, as compared to moves indicative of them embracing. For instance, most if not all coding schemes used the idea of acquiescing (e.g., "agreement", "acceptance", "non-oppositional" or "non-argumentative") as the sole category that was indicative of learners not confronting the socio-cognitive conflicts.

2.2.3 Socio-cognitive Conflict Style Coding Scheme

These issues and the contradictory evidence discussed earlier regarding the effect of socio-cognitive conflicts on cognitive development point to the need to have a valid, reliable, and comprehensive universal coding scheme to more accurately understand and measure how learners respond to socio-cognitive conflicts. These functional conversational moves that learners make in responding to socio-cognitive conflicts represent the observable form of socio-cognitive processes inherent in interactions.

Consequently, using such a coding scheme to analyze interactions among learners enables researchers to gain deeper insights into the complex relationship between socio-cognitive conflict and cognitive development. For example, through comparing studies that have similar ways on how learners respond to socio-cognitive conflicts (i.e., control for socio-cognitive conflict styles), all the aforementioned qualifications and confounding variables (e.g., the type of learning involved) can be investigated more comprehensively to accurately understand the cause of these conflicting results.

To address these issues, Cheng (2011) developed the socio-cognitive conflict style coding scheme (Appendix A). Developed especially for this dissertation study, this coding scheme strives to be a valid, reliable, and comprehensive universal coding scheme that allows researcher to more accurately understand and measure how learners respond to socio-cognitive conflicts that represent the observable form of socio-cognitive processes inherent in interactions. This socio-cognitive conflict style coding scheme was developed through a rigorous development process that was adapted from Gehlbach and Brinkworth's (2011) process of enhancing the validity of survey scales. The development process included: (1) a literature review of key construct (socio-cognitive conflict styles), and closely related constructs (cognitive conflict and conflict behavior styles); (2) development of preliminary functional moves (main and specific) and their indicators based on the literature review and emergent patterns of socio-cognitive conflict responses from a sample of transcripts; (3) an expert validation; (4) cognitive pre-testing; and (5) a pilot test of the coding scheme on a transcript, where high inter-rater reliability statistics (percent agreement (>85%) and Cohen's kappa (>0.80)) were obtained. In Table 2.1, I

provide details of each development phase of this coding scheme and indicate which phase addresses the validity and reliability issues.

Phases	Description	What it addresses
Conceptualization phase		
Literature review	• Review research on theoretical orientation • Review research on conflict behavior styles • Review existing relevant coding scheme (e.g., those that focus on socio-cognitive conflict, social construction of knowledge, and cognitive development)	Validity
Development of the preliminary coding scheme	• Synthesize findings from literature and develop items in the scheme • Test the coding scheme on a sample of middle school students working collaboratively and interacting in a MUVE • Refine the coding scheme based on issues pertaining to clarity, and usability. • Refine the coding scheme based on themes, patterns, phases and/or evidence of the socio-cognitive conflicts that emerged during the testing	Validity (clarity, relevance of items, and representativeness (e.g., any missing categories/indicators)), and usability
Pre-testing phase		
Expert validation	• Consult committee members, experts, and other experienced practitioners on the items in the coding scheme • Refine items based on the findings	Validity (clarity, relevance of items, and representativeness (e.g., any missing categories/indicators))
Cognitive pre-testing	• Ask practitioners/researchers to apply the coding scheme to transcripts of an interaction in MUVE • Observe them as they think aloud their thoughts while they apply the coding scheme to analyze these interactions • Refine items based on the findings	Reliability • How other practitioners/researchers are interpreting the items in the coding scheme • What thought processes are they using to come up with their scoring of the interactions while using the coding scheme
Pilot-testing phase		
Testing and inter-rater reliability	• Have two raters separately apply the refined coding scheme on a transcript. • Obtain percent agreement and Cohen's kappa	Validity and reliability (clarity, relevance of items, and representativeness (e.g., any missing categories/indicators))

Table 2.1. Phases involved in developing the socio-cognitive conflict style coding scheme.

There are five main functional moves of learners' socio-cognitive conflict styles in the socio-cognitive conflict style coding scheme: (1) avoiding; (2) forcing/competing/dominating; (3) compromising; (4) accommodating; and (5) collaborating. Within each main functional move is a set of specific functional moves and their corresponding indicators. The first four functional moves contains specific functional conversational moves that pertain to non-collaborative socio-cognitive processes, whereas the fifth pertains to collaborative socio-cognitive processes. For example, the main functional move of accommodating consists of two observable specific functional moves: (1) emphasizing commonalities; and (2) acquiescing. Emphasizing commonalities refers to stressing areas that most/all group members agree (e.g., Rahim and Magner, 1995). Acquiescing refers to giving in to others' opinions (e.g., Jorczak and Bart 2009) without evidence of any collaborative moves (e.g., clarifying or exploring). As for the collaborating functional move, it consists of seven observable specific functional moves: (1) eliciting; (2) elaborating; (3) clarifying; (4) extending; (5) exploring; (6) qualifying; and (7) synthesizing. For example, eliciting refers to asking others for opinions (e.g., Weinberger and Fischer, 2006). The learner invites others to give opinions on the topic of discussion.

The collaborating functional move is the only one in which the learner embraces the socio-cognitive conflict. There is evidence from the interactions that the learner confronts and faces up to the cognitive dissonances the learner is experiencing. Such cognitive dissonance occurs as a result of the learner's interaction with other group members, where different members provide perspectives/ideas that are different from and/or contradict those of the learner's existing conception of the topic of discussion. The

learner collaborates with others to find a solution that satisfies the needs of all parties (Badke-Schaub, Goldschmidt, and Meijer, 2010). This style is associated with sharing of ideas, and examination of differences to reach a view acceptable to various parties.

In turn, this dissertation study provides an opportunity to provide a large-scale validation study of the reliability of the socio-cognitive conflict style coding scheme using a larger sample of transcripts involving numerous different dyads and pairs of raters to further validate this coding scheme. The pilot test of the socio-cognitive conflict style coding scheme during its development process had involved only one sample of transcripts containing interactions of only one dyad. A review of the literature had indicated that a large number of studies involving content analysis coding schemes either did not report inter-rater reliability or provided insufficient information on it (Lombard, Snyder-Duch, and Bracken, as cited in De Wever et al., 2006). Additionally, some studies using coding schemes were criticized for a lack of details about coding procedures and inconsistency in units of analysis (Rourke and Anderson, 2004). Hence, this study provides an opportunity to validate the coding scheme at a larger scale to obtain indices of inter-rater reliability.

2.3 Scripts in Collaborative Learning

In terms of the implications for the design of collaborative learning environments, the mixed evidence regarding the effect of socio-cognitive conflicts on cognitive development points to fact that it is not sufficient to simply assign group tasks without providing any guidance or scaffolding (Weinberger, Stegmann, and Fischer, 2010). Even though some groups might learn well from one another in collaborative learning and produce higher quality of group performance, other groups might not. On a macro level,

the advantages of combining forces are often negated by process losses due to poor task coordination (Strijbos, Martens, Jochems, and Broers, 2004). On a micro level, students often have insufficient argumentation skills to meaningfully engage in collaborative learning and productively resolve conflicting perspectives (Kuhn, 1991). The emergence of diversity in perspectives is insufficient to guarantee good learning outcomes, but is important primarily because these differences may generate communication among members (Blaye and Gilly as cited in Dillenbourg, Baker, Blaye, and O'Malley, 1996). Unfortunately, the communication can be unproductive. For example, students often settle for quick consensus within the group, rather than take a critical stance toward group members' contributions (Weinberger and Fischer, 2006). Additionally, some students might dominate group discussions and prevent further discussions of other students' perspectives (Weinberger, Stegmann, and Fischer, 2010). Some students might also have difficulties in constructing arguments and counter-arguments when learning in groups (Marttunen and Laurinen, 2001). These different patterns of socialization observed in the classroom (e.g., student-student or teacher-student interaction) could have brought about variation in students' learning.

In this section, the review of the various types and uses of scripts in collaborative learning reveals that the use of external scripts in the form of social scripts offers a promising way to facilitate productive communication among learners in group-work. It can scaffold learners' interactions to help them embrace socio-cognitive conflicts and potentially create patterns of socialization that can improve students' learning. However, a script that leverages a comprehensive range of collaborative socio-cognitive processes has not been developed and tested. Furthermore, the analyses of scripted interactions

usually pertain to argumentative aspects. The lack of use of coding schemes with strong theoretical and empirical underpinnings in socio-cognitive conflicts to measure a comprehensive range of socio-cognitive processes remains an issue, and findings obtained using those coding schemes to analyze interactions might have reliability and validity issues.

2.3.1 Internal and External Scripts

Often, difficulties in obtaining productive student-student interactions that can aid students' learning are due to students' lack of procedural knowledge in constructing and interpreting arguments. Such procedural knowledge is conceptualized as internal scripts (Kollar, Fischer, and Slotta, 2007), which are understood to be a type of cognitive schemata that help individuals understand and take action accordingly (Kolodner, 2007). When faced with both certain familiar and novel situations, individuals understand and act based on their existing beliefs, expectations, repertoire of possible actions, and past experiences. In the case of novel situations, individuals modify them (i.e., existing beliefs, etc.) accordingly to better address each specific novel situation. Hence, it is not surprising that different students in collaborative learning contexts interact differently from one another. Different students have different internal scripts to guide their interaction with other students. For example, students with less elaborated internal scripts might simply reply only "*yes*" or "*no*" to other students' responses, whereas students with more elaborated scripts might give explanations, provide counter-arguments and/or synthesize different students' opinions without being asked to.

To address the issue of variability of students' internal scripts and make collaborative learning more productive, external scripts (also simply referred to as scripts

in this dissertation) have been used in collaborative learning as a specific type of instructional support or scaffolding and is an approach to facilitate effective collaborative learning. Owing to the flexible nature of internal scripts, external scripts can complement and potentially modify students' internal scripts (Kollar, Fischer, and Slotta, 2007). Unlike internal scripts, external scripts cannot be flexibly adapted to changes in the collaborative learning environment and are generally designed prior to collaborative learning. They are typically represented by artifacts such as teachers' hand-outs in the form of paper or instructions in online discussion boards. In general, external scripts aim to provide scaffolding to learners and facilitate knowledge acquisition at the group and individual level to induce specific learning activities in two key ways. External scripts may:

(1) change students' expectations and specify, sequence, and distribute roles and activities at the group level. This reduces process losses typically experienced by students in collaborative learning such as coordination problems (e.g., Strijbos, Martens, Jochems, and Broers, 2004). For example in collaborative writing research, external scripts can facilitate computer-supported collaborative writers through prompts and socio-cognitive structuring (Yarrow and Topping, 2001). This can also facilitate writers to compose a text individually and make revisions with another writer (Veerman and Treasure-Jones, 1999; Zammuner, 1995); and

(2) scaffold meaningful individual learning activities such as structuring interactions that include sound arguments and elaboration of learning materials. For example, scripts can facilitate argumentative activities (Weinberger, Stegmann, Fischer, and Mandl, 2007). Not only does this facilitate the acquisition of domain-specific

knowledge, it also fosters domain-general knowledge, such as the acquisition of argumentative skills (Kollar, Fischer, and Slotta, 2007; Stegmann, Weinberger, and Fischer, 2007).

To maximize the benefits of external scripts, students are encouraged to internalize these external scripts, where students try to make sense of the collaborative learning context with the aid of the external scripts. The use of external scripts was meant to help learners become self-regulated learners (King, 2007). During early stages of the learning process, the facilitation of self-regulated learning involves other-regulation (Kollar and Fischer, 2006). During later stages, other-regulation may be gradually phased away (Pea, 2004). Such phasing away, in which learners progress from other- to self-regulation, is conceptualized as a gradual internalization of external scripts. As learners internalize the scripts, they become increasingly self-regulated learners who are able to interact collaboratively and solve problems by relying primarily on their internal resources, rather than needing an external resource such as an external script. When learners internalize a script, the script becomes more effective since the script is now a smaller load and is more accessible in learners' working memory capacity as compared to external scripts that are not internalized.

Developers of external scripts (e.g., researchers, teachers) need a need to strike an optimal balance between internal and external scripts. On the one hand, although external scripts aim to facilitate productive collaboration by structuring learners' interaction, external scripts can have counterproductive effects if they micromanage what learners are to say and think (Cohen, 1994; Weinberger, Ertl, Fischer, and Mandl, 2005). External scripts that provide high levels of scaffolding may prevent learners from thinking for

themselves. Such a situation is known as over-scripting (Dillenbourg, 2002). Over-scripting is of greater concern especially when the task given in the collaborative learning activities is complex (Cohen, 1994) and when learners are more experienced in the activities they are engaging in (Kollar, Fischer, and Hesse, 2003). On the other hand, external scripts might provide too little help for some students, and thus the use of such external scripts might not be beneficial to students. Such a situation is known as under-scripting (Dillenbourg, 2002). The external script used in this study was designed with issues of over- and under-scripting taken into consideration.

2.3.2 Scripts in Face-to-face and Virtual Group Contexts

Scripts can be used in both face-to-face and virtual group contexts to induce specific learning activities in the two aforementioned key ways. The scripts in the two contexts can have similar as well as different characteristics.

Face-to-face Context

Face-to-face scripted collaboration existed even before computers became ubiquitous learning tools and were aimed to facilitate collaborative learning processes by guiding students to engage in a specific sequence of activities (O'Donnell and Dansereau,1992). Aligned with the two ways external scripts are used to scaffold collaborative learning activities, some of these scripted collaboration approaches in these face-to-face interactions either: (1) specify, sequence, and assign roles and activities to learners during individual and collaborative phases of the learning process; or (2) structure different aspects of learners' interactions or responses. These external scripts are typically represented by physical artifacts (e.g., teachers' hand-outs in the form of paper, written instructions on the board) or verbal instructions. An example of sequencing

activities and learners' thoughts is the six-step program developed by Dansereau and colleagues called "First-Degree MURDER" for collaborative learning (Rocklin et al., 1985). MURDER is an acronym that represents the six-step sequence that guide learner's thinking as they interact and learn. According to Rocklin et al. (1985, p. 67), MURDER refers to:

(1) M – Set a proper mood for learning;

(2) U – Read for understanding;

(3) R – Recall the information;

(4) D – Detect errors or omissions in recall;

(5) E – Elaborate the information into a proper response; and

(6) R – Review the response.

This six-step sequence can be given to students using teachers' hand-outs, and students are encouraged to follow these sequences of thoughts as students engage in collaborative learning activities.

Virtual Group Contexts

More recently, the use of scripts has also been successfully applied to collaborative learning in virtual group contexts (i.e., Computer-Supported Collaborative Learning (CSCL) environments) (e.g., Weinberger, Stegmann, and Fischer, 2010). The use of such online learning environments has gained increasing popularity in various settings (e.g., schools), and knowledge is needed to scaffold students' interactions and collaboration (e.g., through the use of scripts) within these online environments (Häkkinen and Mäkitalo-Siegl, 2007). As similar to scripts used in face-to-face interactions before computers became ubiquitous learning tools, computer-supported scripts specify,

sequence, and assign roles and activities to learners during individual and collaborative phases of the learning process, as well as structure different aspects of learners' interactions that include the quality of the content of interaction or the formal structure of argumentation (Weinberger, Stegmann, and Fischer, 2010). For instance, researchers have found that scripting CSCL induces specific patterns of learner interactions and facilitates learning outcomes beyond what could be achieved without scripting (e.g., Weinberger, Stegmann, Fischer, and Mandl, 2007; Weinberger, Ertl, Fischer, and Mandl, 2005). In particular, the use of scripts in CSCL appears to foster domain-general knowledge such as argumentative knowledge while not at the expense of domain-specific knowledge acquisition (Kollar, Fischer, and Slotta, 2007; Stegmann, Weinberger, and Fischer, 2007).

Nevertheless, scripts within the context of CSCL can have different characteristics as compared to those of face-to-face collaboration, and these characteristics depend on the type of computer (or mobile technology) application and interface that mediates the interaction of learners. In addition to how scripts have been introduced in face-to-face collaborative learning contexts, scripts in CSCL have also been introduced via the design of computer interface (e.g., Scardamalia and Bereiter, 1996). In such approaches, the design of the computer interface can be modified and improved upon for specific collaborative learning activities (Weinberger, Stegmann, and Fischer, 2010). During these modifications and improvements of the computer interface, scripts are integrated into the computer interface to scaffold learners to engage in specific group activities (Dillenbourg, 2002). For example, a scripted computer interface might specify learners to take turns to contribute by restricting a group member access to the computer interface

until another group member has contributed. In such a script, learners are not free to interact whenever they wish. For other CSCL scripts, learners can interact freely or may even be coerced to respond by scripts that provide prompts to ask learners to contribute.

2.3.3 Epistemic and Social Scripts

Be it face-to-face or CSCL contexts, the various types of external scripts include epistemic and social scripts. Aligned with the two ways external scripts are used to scaffold collaborative learning activities, these two types of external scripts facilitate different aspects of collaborative learning. Epistemic scripts specify and sequence the learning task to facilitate knowledge construction activities (Weinberger, Ertl, Fischer, and Mandl, 2005). Relevant concepts are made salient to learners and may require more attention from learners (Suthers, 2003). Through the use of epistemic scripts, each learner's attention is guided toward specific aspects of the task where learners interact in groups during collaborative learning to engage in specific task-oriented activities. Such engagement in turn has been reported to foster knowledge acquisition (Cohen, 1994). Additionally, scaffolding learners' attention to engage in specific task-oriented activities may enhance the productivity of a group working on group tasks, as learners spend time focusing on specific aspects of the task that are designed to aid their learning.

Epistemic scripts can occur in various forms such as in the form of:

(1) <u>visualization aids</u> (e.g., diagram or table). These visualization aids contain characteristics of the group task that involve concepts that are of central importance. For instance, Brooks and Dansereau as cited in Weinberger, Ertl, Fischer, and Mandl (2005) used a script that was aimed at helping students process learning material and learn scientific theories. The script utilized a table

that contained six columns, with each column representing a different aspect of the theory to be learned. In the "Description" column, learners had to describe the key theoretical concepts of the theory at hand. In the "Inventor/History" column, learners had to indicate how the theory came about. In the "Consequences" column, learners had to take note of the implications of the theory. In the "Evidence" column, learners had to fill in the empirical evidence that supported the theory. In the "Other Theories" column, learners had to make connections between the new learning material and their prior knowledge. Lastly, in the "Extra Information" column, learners had to note down any additional information regarding the context of the theory; and

(2) content-specific prompts (e.g., "Which length of the triangle do you need in order to calculate the area of the triangle?"; "What formula can you use to obtain the unknown length of a triangle?"). These prompts scaffold learner's thinking. For example, Dufresne, Gerace, Hardiman, and Mestre (1992) provided learners with questions to help them carry out hierarchically structured, expert-like analyses of the problem given in their task. According to Chi et al. (1981), experts use a top-down approach, where they first classify problems by identifying applicable theoretical concepts, followed by applying a set of procedures that helps them apply specific concepts to solve problems. Dufresne et al. (1992) used prompts to ask learners to first select and define concepts that could be applied to solve the problem given in their task. Dufresne et al. (1992) then used prompts to guide learners to apply those concepts to the problem.

In contrast to epistemic scripts, social scripts specify and sequence interactions of learners to facilitate collaborative learning (Weinberger, Ertl, Fischer, and Mandl, 2005). The key benefit of such scripts in both face-to-face and online virtual groups lies in their focus on the collaboration process between group members. That is, such scripts do not necessarily provide guidance at the conceptual level by, for example, providing content-specific prompts, but rather at the collaboration process level (e.g., "Give a counterargument to your partner's explanation"). More specifically, social scripts aim to help students interact with their group members according to successful interaction patterns of knowledge construction. Such interactions typically involve similar levels of participation among group members and are characterized by different members asking and responding to questions with the involvement of critical negotiation (King, 1994). When students interact in ways as suggested by the script, they should acquire more knowledge from collaborative learning tasks than unscripted students. From a socio-cognitive conflict perspective, students may interact in a more conflict-oriented style, aiming to clear up their own perspectives and integrate the differing perspectives of their group members. Also, social scripts may motivate students to constantly refine their conceptual models because such scripts can help students realize that their contributions to group discussions are being critically reviewed by their group members.

In research studies, such scripts were typically tested under experimental conditions, with an experimental group given a script to scaffold their responses to either group members' responses to them in group tasks or questions given in individual tasks. By contrast, those in a control group were freely allowed to respond in whichever way they preferred. In these research studies, learners' responses were analyzed using coding

schemes, such as those that focus on argumentation components including claim, ground, and qualification (e.g., Weinberger, Stegmann, and Fischer, 2010). In responding to conflicting perspectives, learners who were guided by scripts acquired more both domain-specific knowledge and knowledge of engaging in constructive argumentation than did unscripted learners (Weinberger, Stegmann, and Fischer, 2010). Scripted learners were generally able to put forward their views and substantiate their views with reasons. Scripted learners were also generally able to clarify one another's perspectives and integrate the perspectives of their group members (Weinberger, Ertl, Fischer, and Mandl, 2005).

However, despite recent successes in the use of scripts to create socio-cognitive conflicts as well as to scaffold and analyze learners' interactions (e.g., Weinberger, Stegmann, and Fischer, 2010), the analyses of scripted interactions usually pertain to argumentative aspects (e.g., coding schemes such as Toulmin's (1958) framework of everyday argument). The lack of use of coding schemes with strong theoretical and empirical underpinnings in socio-cognitive conflicts to measure a comprehensive range of socio-cognitive processes remains an issue, and findings obtained using those coding schemes to analyze interactions might have reliability and validity issues. Additionally, a script that leverages a comprehensive range of collaborative socio-cognitive processes has not been developed and tested.

2.4 Group Cognition and Knowledge Convergence

Since the emergence of differences in opinion is less important than the communication it generates to integrate and synthesize differing perspectives to form a shared understanding of the problem and solution, a key outcome of resolving socio-

cognitive conflicts is the advancement in group cognition (i.e., knowledge convergence). Knowledge convergence occurs because the reciprocal nature of collaboration leads to an increased similarity in the cognitive representations of the group members (Jeong and Chi, 2007). It is viewed as a crucial outcome of collaborative learning, playing an important role in explaining the effectiveness of teams (Klimoski and Mohammed, 1994). For instance, the development of shared cognition facilitates coordinated action because this ensures that all participants are solving the same problem and thus helps exploit the cognitive capabilities of the entire team (Orasanu as cited in Klimoski and Mohammed, 1994). Empirical studies have also found positive effects of knowledge convergence on team processes and performances (e.g., Fischer and Mandl, 2005; Mathieu et al., 2000; Mathieu et al., 2005; Lim and Klein, 2006).

The review of group cognition and knowledge convergence in this section surfaces various definitions and types of group cognition. More importantly, among the various measurement methods of group cognition reviewed, cognitive mapping is found to provide a relatively more accurate measure of group cognition. This review also reveals two different sources of knowledge convergence, where convergence may arise due to: (1) the provision of similar learning materials/environments; or (2) an effect of interaction/collaboration.

2.4.1 Different Definitions of Group Cognition and Knowledge Convergence

Various ideas of shared meaning/understanding in group cognition exist with subtle differences in their conceptions. Nevertheless, these different ways generally relate to how groups share knowledge and cognitive processes. According to Thompson and Fine

(as cited in Jeong and Chi, 2007), these varied ways of defining shared meaning/understanding include:

(1) divided up into portions, where this definition focuses on what is different in group members' understanding. According to Jeong and Chi (2007, p. 289), some researchers adopted this definition, using terms such as "distributed cognition (e.g., Hutchins, 1995) and transactive memory (e.g., Wegner, 1987)";

(2) held in common, where this definition focuses on what is similar in group members' understanding. Some researchers adopted this definition, using terms such as "team mental models (e.g., Cannon-Bowers, Salas, and Converse, 1993) and group mind (e.g., Bar-Tal, 1990)" (Jeong and Chi, 2007, p. 289); and

(3) partaking in agreement, where this definition focuses on what is agreed among group members (i.e., common ground as termed by Clark and Brennan (1991)).

The definition of knowledge convergence in this study – an increase in shared knowledge or group cognition – adopts Jeong and Chi's (2007) definition and aligns with the second aforementioned definition of group cognition, namely held in common.

2.4.2 Types of Group Cognition and Knowledge Convergence

Researchers from various fields (e.g., learning science, organizational science, etc.) have argued that there are various types of group cognition (or shared team mental models as termed in organizational science). For example, groups are reported to have group cognition about task requirements, procedures, and responsibilities (Cannon-Bowers, Salas, and Converse, 1993; Klimoski and Mohammed, 1994).

Although different researchers (e.g., Mohammed and Dumville, 2001; Cannon-Bowers, Salas, and Converse, 1993) have suggested different descriptions to represent

different types, the different types of group cognition overlap and generally pertain to at least four key content domains of shared knowledge:

(1) Technology or equipment. This shared knowledge pertains to the dynamics and control of technology/equipment with which group members are using and how technology/equipment affects the interaction of group members (Mathieu, Heffner, Goodwin, Salas, and Cannon-Bowers, 2000);

(2) Task. This shared knowledge "describes and organizes knowledge about how the task is accomplished in terms of procedures, task strategies, likely contingencies or problems, and environmental constraints" (Mathieu et al., 2000, p. 274). In this case, the corresponding knowledge convergence can be specifically referred to as task convergence, which is the increase in group cognition of the task(s) at hand;

(3) Group interaction. This shared knowledge pertains to how the group interacts and what is known or believed by team members with regard to what are appropriate or effective processes. Minionis, Zaccaro, and Perez (as cited in Mohammed, Klimoski, and Rentsch, 2000) referred to this as a team interaction model, whereas Rentsch and Hall (1994) termed this as teamwork schema. This type of group cognition includes shared knowledge about the "roles and responsibilities of group members, interaction patterns, information flow and communication channels, role interdependencies, and information sources" (Mathieu, Heffner, Goodwin, Salas, and Cannon-Bowers, 2000, p. 274); and

(4) Group member characteristics. This shared knowledge pertains to information on group members, including group members' knowledge, skills, attitudes, strengths, weaknesses, etc (Cannon-Bowers, Salas, and Converse, 1993).

2.4.3 Key Methods of Measuring Group Cognition and Knowledge Convergence

It is difficult to measure the extent of knowledge convergence in a clear-cut manner, with few studies in the learning sciences that have measured knowledge convergence quantitatively (e.g., Fischer and Mandl, 2005; Jeong and Chi, 2007). According to Jeong and Chi (2007), research studies have either generally assumed that collaboration will lead to knowledge convergence or undertaken qualitative analyses to understand the extent of knowledge convergence (e.g., Teasley and Roschelle, 1993). Typically, two different aspects of group cognition need to be determined: (1) the elements (i.e., the content/knowledge aspect); and (2) the statements, which are the relationships between the elements (i.e., the structural aspects of the content/knowledge). To date, researchers have used various methods to measure group cognition and thus knowledge convergence. These include:

(1) likert-scale questionnaires, especially for studies that did not consider representation or structure of group cognition (e.g., Mohammed and Ringseis, 2001);

(2) relatedness ratings, where participants were asked to rate the relatedness of elements provided by the researcher (e.g., Mathieu et al., 2000; Stout, Cannon-Bowers, Salas, and Milanovich, 1999);

(3) concept mapping, where participants were asked to choose from a range of elements and place them in a pre-specified hierarchical structure (e.g., Marks, Sabella, Burke, and Zaccaro, 2002); and

(4) cognitive mapping, where elements and statements are identified from the texts responses of participants (e.g., Carley, 1997).

In Table 2.2, I present details of some examples of the various methods to measure group cognition.

Measurement methods	**Key characteristics**	**Example of studies**	**Details of one study**
Likert-scale questionnaires	Did not consider representation or structure of group cognition	Mohammed and Ringseis (2001); Ensley and Pearce (2001)	For example, Mohammed and Ringseis (2001) used the degree of variation of group members' responses on five questions, where each question utilized a 7-point likert-scale, to understand the similarity of how members interpreted the task at hand.
Relatedness ratings	Individual participants used a likert-scale to rate the relatedness of elements on pairs of elements provided by the researcher	Mathieu et al. (2000); Stout, Cannon-Bowers, Salas, and Milanovich (1999)	For example, Stout et al. (1999) used computer programs such as Pathfinder to analyze the relatedness ratings given by participants in order to generate each participant's mental model. Similarity/overlap between group members' mental models is considered the group cognition.
Concept mapping	Participants were asked to choose from a given range of elements and place them in a pre-specified hierarchical structure	Marks, Sabella, Burke, and Zaccaro (2002)	For example, Marks et al. (2002) used the percentage of concepts that were placed identically on concept maps among group members as an indicator of group cognition.
Cognitive mapping	Elements and statements are identified from the texts responses of participants	Carley (1997)	An example using Carley's (1997) method is shown in Appendix B.

Table 2.2. Measurement methods for group cognition.

Only the last approach elicits the elements and statements from participants. Cognitive mapping enables an accurate mental model of each participant to be obtained,

where the network of statements of each participant represents his mental model. The main disadvantage of this approach is that it is tedious to conduct cognitive mapping if there are long text responses and large number of participants. Unlike cognitive mapping, the first three approaches require participants to choose among given elements. Given that these elements are pre-determined and imposed upon participants to choose even if the participants might not possess such elements, these 3 approaches might potentially lead to false mental models of participants.

2.4.4 Different Sources of Knowledge Convergence

Knowledge convergence is not always attributable to interaction/collaboration despite some researchers' assumption that an increase in group cognition occurred as a result of interaction/collaboration (Jeong and Chi, 2007; Fischer and Mandl, 2005). According to Jeong and Chi (2007), this assumption was made because during interaction/collaborative, group members jointly interpret a problem and its background/context, coordinate their understanding of the complexities that the problem presents, and contribute their knowledge and expertise to jointly formulate solutions to the problem. An increase in similarities in their representations is therefore assumed to be due to such joint construction activities.

However, such an increase does not necessarily mean that shared knowledge was developed through interaction/collaboration. Group members could be constantly exposed to shared materials/input such as news media, books and teacher handouts, and it is possible that these shared materials/input could lead to knowledge convergence (Jeong and Chi, 2007).

As such, in general, two different sources of knowledge convergence can be distinguished, though existing studies seldom distinguish between these two sources of convergence (Jeong and Chi, 2007; Fischer and Mandl, 2005). First, convergence may arise because partners who collaborated were provided with the same learning material and/or were exposed to the same learning environment. Second, convergence may occur as an effect of joint interaction. The source of knowledge convergence can be determined by comparing real groups (i.e., students who actually collaborated) with post hoc nominal groups as control groups in the research design (e.g., Jeong and Chi, 2007), where post hoc groups are formed by grouping students who had not collaborated during the actual group activities.

2.5 Summary

Variation in the learning outcomes of collaborative learning within the socio-cognitive conflict paradigm has led to the importance of examining group processes via interactions to gain deeper insight into leveraging socio-cognitive conflict more effectively for cognitive development and group performance. Rather than mere disagreement, it has been posited that group-work will only be beneficial to learners and their group if divergence in meaning leads to further negotiation by argument and clarification toward mutually shared cognitions (Van den Bossche, Gijselaers, Segers, and Kirschner, 2006) and thereby results in knowledge convergence. Viewed as a crucial outcome of collaborative interactions, knowledge convergence plays an important role in explaining the effectiveness of groups (Klimoski and Mohammed, 1994).

The mixed evidence regarding the effect of socio-cognitive conflicts on cognitive development also points to the fact that: (1) interactions have not been analyzed using

instruments developed with theoretical and empirical underpinnings within a socio-cognitive conflict paradigm to measure a comprehensive range of socio-cognitive processes; and (2) it is not sufficient to simply assign group tasks without providing any guidance or scaffolding (Weinberger, Stegmann, and Fischer, 2010). The use of a social script offers a promising way to facilitate productive communication among learners in group-work. However, despite successes in the use of social scripts to specify and sequence interactions of learners to create socio-cognitive conflicts and facilitate collaborative learning, the analyses of scripted interactions usually pertain to argumentative aspects (e.g., using coding schemes such as Toulmin's (1958) framework of everyday argument) rather than a comprehensive range of socio-cognitive processes. This could result in findings that have reliability and validity issues.

Taking all these together, one possible approach to gain insight into leveraging socio-cognitive conflict more effectively is to use instruments with empirical and theoretical underpinnings to investigate the relationship between socio-cognitive processes inherent in interactions and the extent to which learners experiencing socio-cognitive conflicts will advance in their shared knowledge and have knowledge convergence. One such instrument that can be used to analyze interactions is the socio-cognitive conflict style coding scheme, which can measure a comprehensive range of socio-cognitive processes. Furthermore, given the success of a script in facilitating interactions, a script that leverages a comprehensive range of collaborative socio-cognitive processes can first be tested to examine whether scripted interactions contain higher frequency of collaborative socio-cognitive processes. Subsequently, the variation of collaborative socio-cognitive processes in interactions can be used to investigate the

effect of collaborative socio-cognitive processes on knowledge convergence and consequently on the quality of group performance. I posit that interactions containing higher frequency of collaborative socio-cognitive processes can help learners engage in a constructive argumentation process to understand and integrate group members' perspectives. This will in turn resolve their socio-cognitive conflicts and thus develops their group cognition to result in knowledge convergence. Based on this argument and the information presented in Chapters 1 and 2, I formulate the three research questions in the next chapter, together with their corresponding hypotheses and the research design to address these questions.

CHAPTER 3

RESEARCH QUESTIONS AND DESIGN

Having presented the background and context as well as the research purposes of this study in Chapter 1 and an in-depth literature review of the various research strands underpinning this study in Chapter 2, I now define the specific research questions and design of this study in this chapter. In the sections that follow, I present the: (1) specific research questions; (2) data set; (3) experimental conditions; (4) tasks and procedures; (5) measures and instruments; and (6) data analytic plan.

3.1 Research Questions

The literature review in Chapter 2 reveals contradictory evidence regarding the effect of socio-cognitive conflicts on cognitive development, indicating that it is not sufficient to simply assign group tasks without providing any guidance or scaffolding (Weinberger, Stegmann, and Fischer, 2010). The use of scripts is a promising way to facilitate the type of productive communication to make group-work beneficial. Additionally, group-work will only be beneficial to learners and their group if divergence in meaning leads to further negotiation by argument and clarification toward mutually shared cognitions, consequently resulting in higher quality of group performance. Taking these together, I formulated three research questions with their corresponding hypotheses shown in Table 3.1.

S/N	Research Question	Hypothesis
RQ1	*To what extent, if at all, are interaction processes affected by a collaborative socio-cognitive process script (with versus without)?*	Dyads using the collaborative socio-cognitive script (Appendix C) will have interactions with higher frequency of collaborative socio-cognitive processes compared to dyads without any script.
RQ2	*To what extent, if at all, is task convergence affected by collaborative interaction processes? Can the source of the effect be attributed to collaboration/interaction?*	Interactions with higher frequency of collaborative socio-cognitive processes will positively influence the level of task convergence. The source of this influence can be attributed to the collaboration/interaction.
RQ3	*To what extent, if at all, are group performances affected by task convergence?*	Dyads with higher levels of task convergence will produce group products that are of higher quality than those produced by dyads with lower levels of task convergence.

Table 3.1. Research questions and hypotheses.

3.2 Data Set

I invited 163 grade nine students from a Singapore secondary school to participate in this study, which consisted of two sessions held approximately two weeks apart. The parent consent and student assent letters are attached in Appendices D and E respectively. Of the 163 students I invited, 142 participated throughout the whole duration of the study. Those who did not either were absent from school on at least one of the sessions or they (or their parents) had opted not to participate beforehand. These 142 students were randomly paired to form 71 dyads[4]. Over-sampling by inviting more students than my

[4] I formed dyads, rather than groups of three or more members, so as to have a larger sample at the group level, thereby providing higher statistical power. Consequently, there are some design trade-offs that should be noted. For example, there are potential for more socio-cognitive conflicts in groups of three or more members as compared to dyads. Group dynamics could also be different in dyads versus groups of more than three members (e.g., sub-groups are not possible in dyads but may form in groups of three or more members). Nevertheless, using dyads, instead of groups of three or more members, might help keep the focus of the research on interactions, rather than introduce other confounding factors such as group dynamics.

intended sample size was deliberately done to obtain a resulting sample of 71 dyads that was more than, if not at least equivalent to, the typical sample size of 16-50 groups of participants in other quantitative experimental studies involving scripts (e.g., 16 and 32 groups in Weinberger, Stegmann, and Fischer (2007) and Weinberger, Ertl, Fischer, and Mandl's (2005) studies respectively).

Although students from any grade level are suitable to address my research questions, grade nine students were recruited due to the pre-requisite skills required to address the over-arching real-world problem (to be described later) requested by the school to be assigned to students in my study. Those skills include problem-solving, data collection, and data analysis, which are typically taught during grade eight or nine.

I obtained an Institutional Review Board approval prior to carrying out this dissertation study. The Harvard University Committee on the Use of Human Subjects (CUHS) in research approved my application to conduct this study on human subjects (grade nine students in this case). A copy of the notification of exemption determination letter from the CUHS is attached in Appendix F. Additionally, I obtained approval from the Singapore Ministry of Education (MOE) to conduct this dissertation study using a sample of students from a public school in Singapore; MOE's approval letter is attached in Appendix G.

3.3 Experimental Conditions

Dyads were randomly placed into either an experimental or control group. For the experimental group, each dyad was given a collaborative socio-cognitive process script and a qualified teacher taught a range of functional conversational moves (collaborative and non-collaborative). The teacher highlighted which were the collaborative functional

conversational moves and emphasized that students should interact using these collaborative moves. During any pair discussions in this study, students were encouraged to reply to their partners' responses using any collaborative moves until they agreed fully with what their partners had put forward. The list of collaborative moves and corresponding examples of how to interact using these moves served as the script to scaffold interactions (Appendix C). This list was always made visible to students in the experimental group.

As for the control group, a range of functional conversational moves were also shared with students, but these were shared without deliberately highlighting which were the collaborative functional conversational moves and without any emphasis made on the collaborative functional conversational moves. Instead, it was emphasized that students should interact freely in any pair discussions as how they typically interact with their friends. No script was given to these students.

3.4 Tasks and Procedures

Both groups attended two computer-laboratory sessions held approximately two weeks apart, each lasting less than two hours. All the tasks and procedures as well as any lectures/instructions and their durations given to both groups were similar (see detailed lesson plan in Appendix H) except for the only differences described in Section 3.3.

3.4.1 Session One: Description of Tasks and Procedures

In session one, prior to entering the computer laboratories, students from the control group first reported at a lecture venue, whereas students from the experimental group reported at another different lecture venue. During their lectures at the respective venues, both groups learned a simplified problem-solving process (Appendix I) and

became acquainted with various functional conversational moves. The lecture content in the two venues was similar, except for the difference in the emphasis pertaining to the functional conversational moves as described in Section 3.3. Immediately after the lecture, students were led to their assigned computer laboratories. Four computer laboratories, each with 40 computers, were used in this study. Two of these laboratories were used to host students from the experimental group, whereas the other two laboratories hosted students from the control group. To mimic authentic online collaborations and ensure that interactions occurred entirely online, members from the same dyad were assigned to different computer laboratories. During the two computer-laboratory sessions, students addressed the following over-arching real-world problem[5]:

> *"How can a class work together to create a clean and conducive classroom environment for teaching and learning?"*

This over-arching real-world school problem consisted of specific problems that related to two broad areas:

(1) Clean environment. Any issues that pertains to cleanliness that might affect students' learning; and

(2) Conducive environment. Any issues that can affect students' learning (e.g., noisy classmates that distract students from paying attention in class).

To motivate and engage students to focus on addressing the school problem, students were given autonomy to identify any specific school problem(s) that mattered most to them and which related to either of these two broad areas. The school also informed students that the school believes students can provide good suggestions to improve the learning environment and will recognize students' suggestions by

[5] The school involved in this study requested this problem to be given to students.

considering and implementing the best suggestions. Students whose suggestions were adopted would be recognised during a school assembly. Giving students autonomy and making them feel competent that they can make a change in an area that matters to them might motivate them to stay focused on the tasks (Ryan and Deci, 2000).

While in the computer laboratory, an instructor guided students through the simplified problem-solving process they learnt during the earlier lecture via the specially designed web-based interface shown in Figure 3.1. The steps in the computer interface aligned with the steps in the problem-solving process. These steps were also consistent with the questions (and the order in which these questions were asked) in the pre- (Appendix J) and post-surveys[6] (Appendix K). For example, step 1 in the computer interface shown in Figure 3.1 corresponded to question 1 in the pre-survey and asked students to individually identify a specific school problem and to give possible initial solutions to the problem. This was also the first step in the problem-solving process (see Appendix I for the steps in the problem-solving process). As an example of how questions in the pre- and post-surveys appeared in an online format, the computer interface of question 1 in the pre-survey is shown in Figure 3.2. Step 2 in the computer interface, which corresponded to the remaining sets of questions in the pre-survey, asked students to think on their own about the strategies they could use to collect data/information that could be used to address the specific school problem they had identified. More specifically, students were asked these sets of questions: (1) What information and data do students need in order to make informed decisions on what the solutions are; (2) How can students collect that information and data; (3) Who can

[6] Printed copies of the pre- and post-survey questionnaires were also given to students. Students could choose to write on a printed copy of the pre- and post-survey questionnaires instead of submitting their responses online.

students collect these from; (4) What is the sample size (if applicable); and (5) How can students analyze their data to come up with their proposal to address the school problem they had identified?

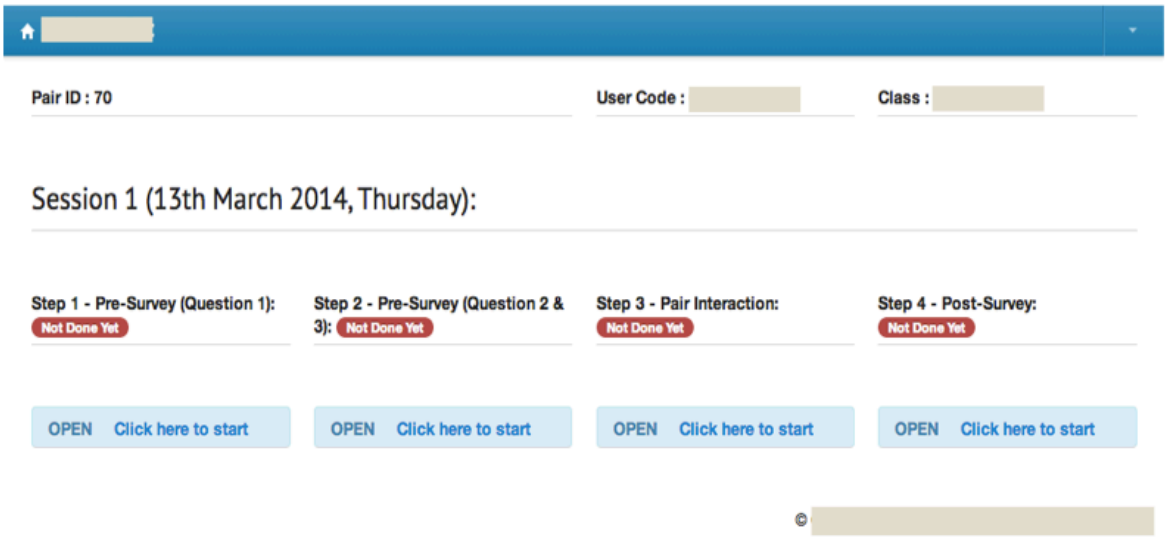

Figure 3.1. Screen capture of the web-based interface that was used in session one.

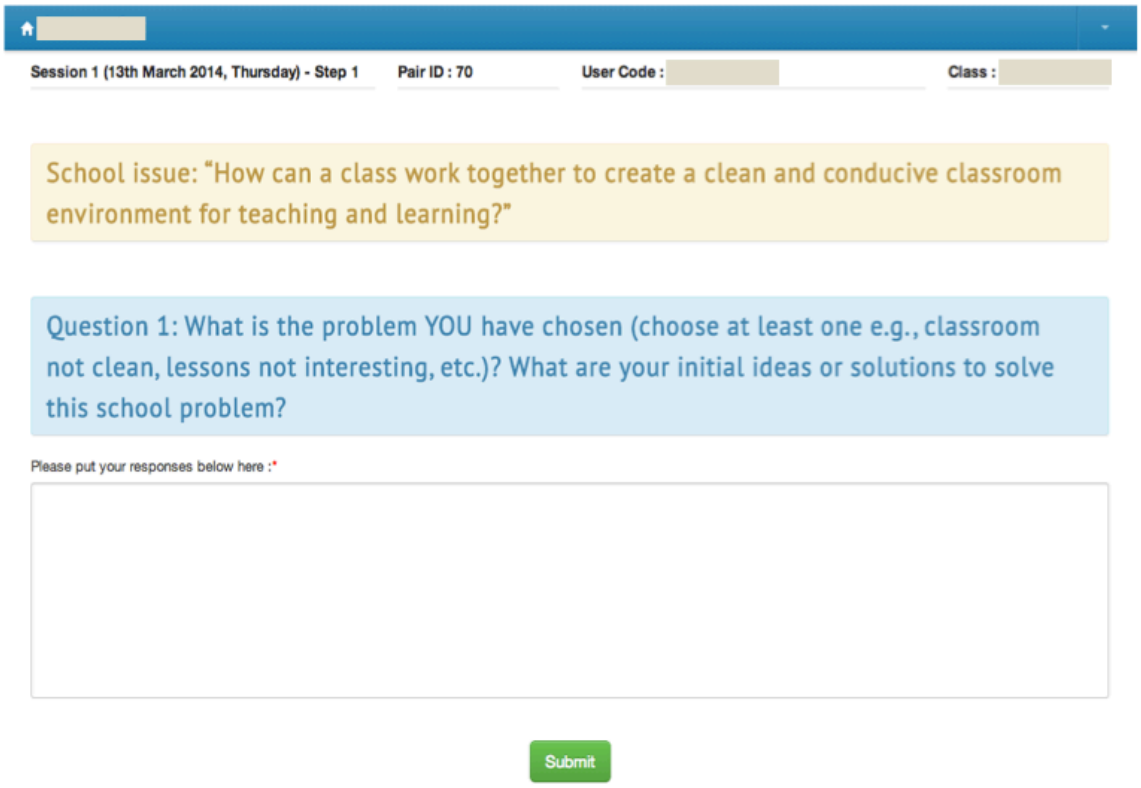

Figure 3.2. Screen capture of one of the questions asked to students in session one.

Following the individual work in steps 1 and 2 in the computer interface, students were given the opportunity to discuss with their partners from another computer lab by proceeding to step 3 in the computer interface. During this step, each student had to interact online and share with their partner all the ideas he/she had come up with in step 1 and 2. During the online interaction, each pair had to discuss and agree on a common specific school problem and the strategies to obtain data/information that could help them address the problem. The instantaneous chat interface is shown in Figure 3.3.

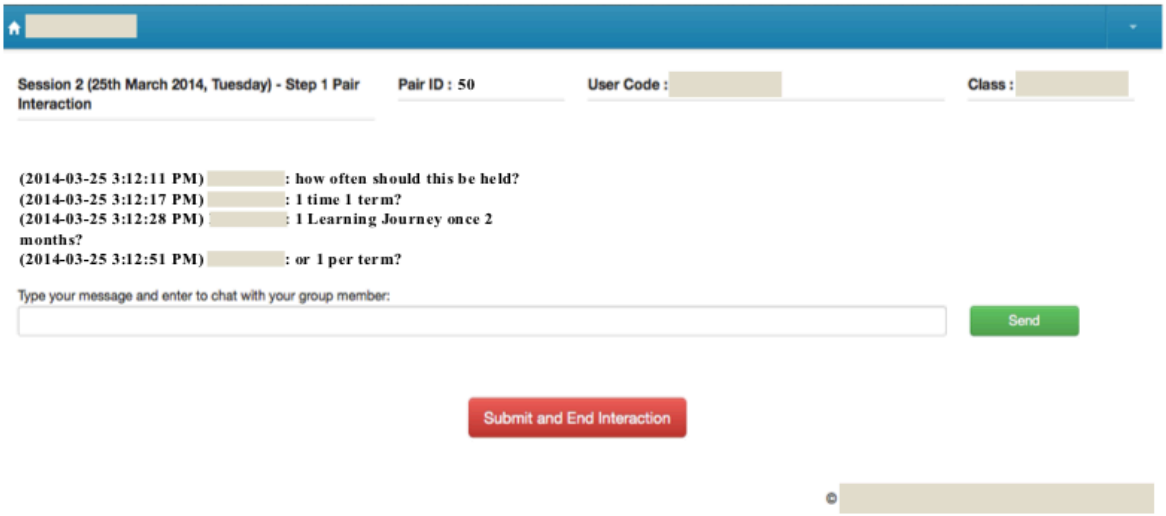

Figure 3.3. Screen capture of the instantaneous chat interface used in this study. It shows an authentic chat history between two persons.

Following their online discussions with their partner, students were instructed to proceed to step 4 (i.e., the last step) in the computer interface, which was to respond to the questions asked in the post-survey (Appendix K). Students were instructed to individually write down what they perceive to be their pair's identified problem and strategies to obtain data/information that could help them address the problem. Before the session concluded, students were encouraged to obtain data/information prior to session two using those strategies they had developed.

3.4.2 Session Two: Description of Tasks and Procedures

In session two, students reported directly to their assigned computer laboratories. They first interacted online (using the same online interaction platform as session one) with their same partner from session one to formulate their pair's proposals to address the school problem they had identified. The four questions in the group proposal survey form (Appendix L) were given to them to guide their discussion. They then submitted their proposal by answering those four questions. The screen capture of the web-based

interface that was used in session two is shown in Figure 3.4, where step 1 corresponded to the online interaction with their partners, and step 2 corresponded to filling up details of the pair's proposal[7].

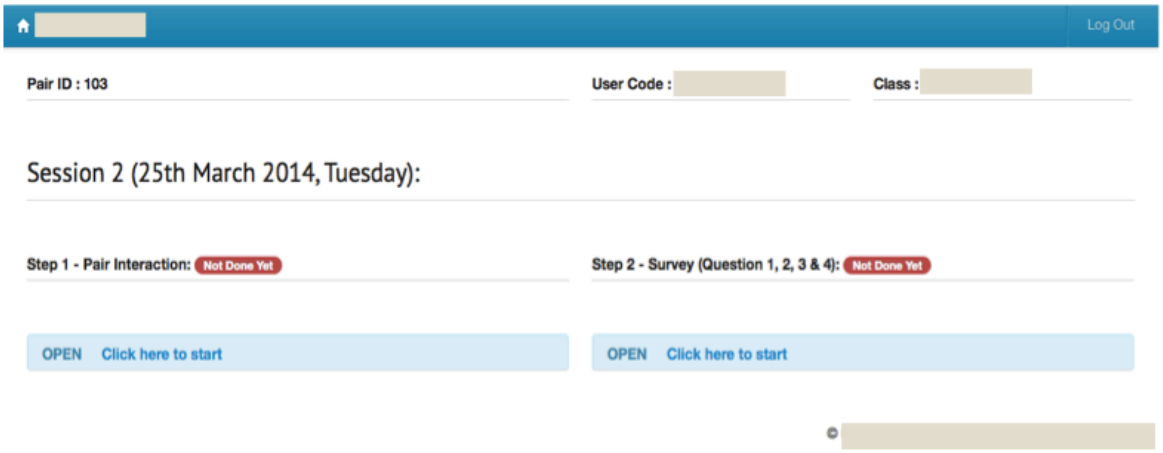

Figure 3.4. Screen capture of the web-based interface that was used in session two.

3.4.3 Summary of Tasks and Procedures for Experimental and Control Group

In Table 3.2, I summarize the: (1) activities conducted in the two sessions (see detailed lesson plan in Appendix H); (2) differences between experimental and control group; and (3) specific tasks (one individual and two group) that guide students to address the over-arching real-world problem.

[7] A printed copy of the group proposal survey form was also given to students. Students could choose to write on a printed copy of the group proposal survey form instead of submitting their responses online.

Time	Experimental group	Control group
	Session One	
25 min	• Students report at room one. • A qualified teacher teaches students a range of functional conversational moves. • *Teacher highlights collaborative moves and emphasize that they should use collaborative moves during any group tasks.* • Teacher conducts mini-quiz to assess how well they have learnt. Examples of hypothetical interaction transcripts will be shown to students. Some students will be randomly selected to ask them to: (1) identify what moves are used in those examples, and (2) use one of the specific moves to give a response to the last line of the transcripts.	• Room two. • Same. • *Interact freely.* • Same.
20 min	• Teacher familiarizes students with a simplified problem-solving approach (Appendix I). Students proceed to assigned computer rooms.	• Same.
15 min	• Research assistant (RA) asks students to do **individual task**: "On you own, think of strategies on how to obtain data that you can use to come up with solutions to the school problem." For example, one strategy to obtain data could be to search the Internet for suggestions on how to encourage students to maintain a clean classroom environment. • RA conducts pre-survey (Appendix J) to all students to obtain their strategies on how to obtain data and current knowledge of possible answers/solutions.	• Same. • Same.
30 min	• RA asks students to do **group task one**: "In pairs, come up with strategies on how to obtain data that your group can use to come up with solutions to the real-world problem." Dyads interact via an online synchronous chat tool. • *Script is provided; Use of collaborative moves is reminded.*	• Same. • *Not provided.*
10 min	• RA conducts post-survey questionnaire (Appendix K) to obtain what students perceive their group's strategies to be.	• Same.
	Session two	
50 min	• RA asks students to do **group task two**: "Share with your partner the information/data you had obtained and collaboratively develop concrete plans to create a clean and conducive classroom environment for teaching and learning." • *Script is provided; Use of collaborative moves is reminded.* • Each pair submits one group proposal containing their plans.	• Same. • *Not provided.* • Same.

Table 3.2. Summary of: (1) activities; (2) differences between experimental and control group; and (3) specific tasks (individual and group) in the two sessions.

It should be noted that the design of the tasks and procedures were meant to aid students' collaboration. More specifically, the combination of individual and group tasks were designed to help students work together to address the real-world problem faced by the school. Such combination of individual and group tasks has been shown to aid collaboration (Rummel and Spada, 2005). Giving students time to individually think about issues that are subjective allows students to come up with their own ideas without social pressure and without others influencing their thinking (Baker, 2003). Having given thought about the issues at hand and derived their own ideas, students will be better prepared to engage in more productive interactions with group members (Weinberger, Stegmann, and Fischer, 2007).

It would also be noted that the over-arching group task that involves addressing the over-arching real-world problem (via group tasks 1 and 2) is group-worthy. First, it is open-ended without one definite answer. Second, it allows students with different abilities to contribute in different ways. For example, some students might be better in analyzing data and others in collecting data. Third, it involves important problem-solving skills that are necessary to excel in studies and future work-life. Fourth, it requires positive interdependence as students contribute different ideas/data to help them make decisions. There is also individual accountability as students will share their ideas and any data/information they obtain. Lastly, students will be made aware of the grading rubric for the group product.

3.5 Measures and Instruments

In Table 3.3, I describe the variables used in my study.

Variable	Description
SCRIPT	1: if student is in experimental group 0: if student is in control group
COLLAB	The frequency of collaborative socio-cognitive processes in each dyad's chat-log
NON-COLLAB	The frequency of non-collaborative socio-cognitive processes in each dyad's chat-log
ELEMENT	Task convergence (element)*
STATEMENT	Task convergence (statement)*
PERFORMANCE	Group performance (i.e., the marks given to each dyad's submitted proposal containing their suggested concrete action plan)

* This will be elaborated under the section "Group cognition and task convergence".
Table 3.3. Variables used in the study.

3.5.1 Collaborative and Non-collaborative Socio-cognitive Processes

To obtain *COLLAB* and *NON-COLLAB*, a rater and I used the socio-cognitive conflict style coding scheme (Appendix A) to code text-based chat-logs of all dyads that were obtained during the two group tasks[8]. The use of the coding scheme can help identify a comprehensive range of functional conversational moves. As described previously in Section 2.2.3, it contains five main categories: avoiding, forcing/competing/dominating, compromising, accommodating, and collaborating. The first four pertain to non-collaborative socio-cognitive processes, whereas the last pertains to collaborative socio-cognitive processes. Each category further contains specific functional conversational moves.

To code each dyad's chat-log[9], I first considered each utterance in the chat-log as a raw data unit. Similar to Kapur and Kinzer's (2007) analysis of synchronous online interactions, each utterance is defined as every word that a student typed on the keyboard

[8] Using chat-logs obtained during group task one (i.e., session one) yielded one set of measures for *COLLAB* and *NON-COLLAB*, whereas using chat-logs obtained during group task two (i.e., session two) yielded another set of measures for *COLLAB* and *NON-COLLAB*.
[9] Any portion of the chat-log that did not relate to the task was first filtered out (e.g., chit-chat on issues unrelated to task). Only utterances that relate to the discussion of the task were coded.

before hitting the "Enter" button[10]. Next, a rater and I separately segmented each utterance into one of the main categories in the coding scheme (which I call an interaction unit). This interaction unit is defined as the function that each utterance serves within the context of the conversation (e.g., compromising). It is important to situate each utterance within the context of the conversation in order to comprehend the chat-log (Bransford and Nitsch as cited in Kapur and Kinzer, 2007). Finally, each rater further coded each interaction unit into one of the specific moves stated in the coding scheme.

Based on a rater and my coding results, I calculated two sets of inter-rater reliability indices to provide an understanding of the inter-rater reliability. The indices are percent agreement and Cohen's kappa that pertain to assigning:

(1) each utterance into an interaction unit; and

(2) each interaction unit into a specific move.

3.5.2 Group Cognition and Task Convergence

To obtain measures of group cognition (and task convergence), the concepts of element and statement need to be elaborated first:

(1) An element is a single ideational category that can be observed from the student's text-based responses to the surveys. For example, an element can be: (1) a single word (e.g., "survey"); (2) a composite word (e.g., "classroom rules"); or (3) a more complex phrase (e.g., "equal and fair distribution"); and

(2) A statement is the relation between two elements. For example, the statements, "There should be equal and fair distribution of classroom duties" and "Set up a

[10] Any utterance after the "Enter" button was considered the same utterance as the immediate previous one before the "Enter" button (i.e., all these utterances were treated as one utterance) if the utterance after the "Enter" button was simply: (1) a correction of spelling mistakes of words from the immediate previous utterance; or (2) a continuation of an uncompleted sentence from the immediate previous utterance.

duty roster", can each be coded as a relation between two elements: "equal and fair distribution + classroom duties" and "set up + duty roster" (Figure 3.5).

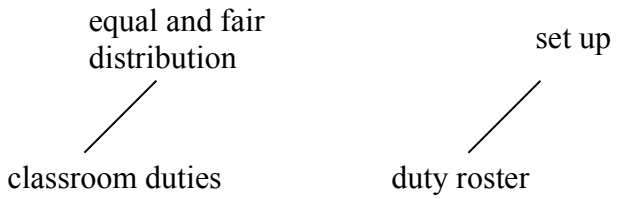

Figure 3.5. Two examples of a pair of elements joined together by a line to form a statement.

I computed two sets of measures, with the first and second set corresponding to group cognition before and after the group task in session one respectively. Each set consisted of two quantitative measures, namely group cognition (elements) and group cognition (statements), which were the number of identical elements and statements in both students' responses from the same dyad to the pre-survey (for first set of measures) or post-survey (for second set).

The following process to obtain *ELEMENT* and *STATEMENT* was adopted:

(1) The pre-survey asked each student for his own specific strategy that he used to obtain data to make informed decisions to address the real-world problem. The post-survey asked each student for the corresponding strategy that he perceived to be agreed between he and his partner;

(2) I used Carley's (1997) cognitive mapping method[11] on students' responses to the pre- and post-surveys to obtain the elements and statements:

   (a) <u>Elements</u> were identified through a filtering process, where the rater determined whether any words should be deleted or generalized based on

[11] Carley indicated that the reliability and validity of the method are satisfactory.

a delete and thesaurus list (Appendix M). The delete list contained all trivial words (e.g., conjunctions, et cetera). The thesaurus list contained two types of generalization to classify different words as the same element: words with (1) similar meaning (e.g., survey and questionnaire were both be known as the element "survey") and (2) identical base (e.g., classmate and classmates were both be known as "classmate"). Both lists were made in consultation with experienced teachers and were improved upon based on students' responses;

(b) Statements from the resulting elements from the filtering process were identified through a windowing process with the window size set at four to identify relations[12].

This method stays close to the data to extract both elements and statements. It determines whether the text's authors are just using identical words or are actually exhibiting shared meaning.

(3) Using the elements and statements coded from the pre- and post-surveys, group cognition (elements and statements) before and after the group task in session one were computed. An example using Carley's method is given in Appendix B; and

(4) *ELEMENT* (and *STATEMENT*) were calculated using the increase/decrease in group cognition for elements (and statements) before and after the group task in

[12] I expect grade nine students' survey responses to be rather short in general. Hence, window of four should be sufficient. To illustrate, consider the sentence: "Search the internet for ideas on ways to encourage cleanliness in classrooms". After filtering, we obtain: "Search internet ideas ways encourage cleanliness classrooms". Using a window of four results in these relations: "search-internet", "search ideas", "search-ways", "internet-ideas", "internet-ways", "internet-encourage", "ideas-ways", "ideas-encourage", "ideas-cleanliness", "ways-encourage", "ways-cleanliness", "ways-classrooms", "encourage-cleanliness", and "cleanliness-classrooms".

session one, where increase and decrease indicate convergence and divergence respectively.

3.5.3 Group Performance

I obtained *PERFORMANCE* by grading each pair's proposal using a rubric (Appendix N) that I have developed and which has been vetted by the school. This yielded an overall numerical score from assessing the quality of these dimensions: originality, team plan, data collected, data analysis, data collection instrument, and documentation of data sources. Graders did not know whether proposals belong to the experimental or control group, as proposals were identified using students' personal identity numbers.

3.6 Data Analytic Plan

The data analytic plan involved two key stages. The first stage focused on a large-scale validation of the reliability of the socio-cognitive conflict style coding scheme (Appendix A). As highlighted in Chapters 1 and 2, it is critical for this study to use a coding scheme that shows evidence of reliability and validity, and is capable of identifying a comprehensive range of functional conversational moves that represent the observable form of socio-cognitive processes inherent in interactions. The first stage of this study involved a rater and I testing the coding scheme on numerous samples of transcripts that contained interactions between two students. Each sample consisted of different interactions involving different dyads, and the total amount of interactions that were randomly selected for this testing of coding scheme was about 10-20% of the total interactions that occurred in this current study. Prior to the actual coding of the transcripts, I gave about four hours worth of training to the rater so that he would be

familiar with the content of the coding scheme and knew how to code a sample transcript using the coding scheme. The training included opportunity for the rater to clarify some of his understanding of the functional conversational moves and indicators given in the coding scheme.

I obtained the inter-rater reliability indices of percent agreement and Cohen's kappa, before and after negotiation with the other rater over our coding results. Although there is no general agreement on what reliability indexes should be used, De Wever et al. (2006) suggested that researchers should report two indices to provide more information to readers in order for other researchers to gauge for themselves the reliability. One index should report the percent agreement and the other index should be one that also accounts for agreement by chance (e.g., Cohen's kappa). As such, based on the other rater and my coding results, I calculated the percent agreement and Cohen's kappa. Unlike most other studies in which there was only one set of inter-rater reliability indices, my process yielded two sets of inter-rater reliability indices to provide a more robust understanding of the inter-rater reliability for the coding scheme to better inform researchers of its reliability: (1) One set consists of the percent agreement and Cohen's kappa, which pertains to assigning each utterance[13] into one or more interaction unit; and (2) the other set consists of the same two indices, but the two indices pertain to assigning each interaction unit into one of the indicators in the coding scheme. The first set of inter-rater reliability is similar to segmentation reliability (Strijbos, Martens, Prins, and Jocherns, 2006), where researchers evaluate how reliable the results of the segmentation of the transcripts into unit of analysis are by different researchers.

[13] In this study, any sentences that were truncated and separated into several utterances were treated as one utterance.

Before conducting the second stage of the data analytic plan, I examined the effectiveness of random assignment of students into control/experimental group. I obtained group cognition (elements and statements) using students' responses to the pre-survey and conducted t-tests to compare whether the control and experimental groups differ.

Finally, the second stage of the data analytic plan involved using the coding scheme to quantify students' interactions to obtain *COLLAB* and *NON-COLLAB* and applying statistical analyses to address the specific research questions in this study. The rest of this section describes details of the statistical analyses that were conducted to address research questions one to three.

RQ1: To what extent, if at all, are interaction processes affected by a collaborative socio-cognitive process script (with versus without)?

I regressed *COLLAB* on *SCRIPT* to examine whether there is an effect of the script on socio-cognitive processes. I interpreted the coefficient of *SCRIPT*, particularly on the size and direction of any detected effects. I expected the coefficient to be positive, aligned with my hypothesis and findings from literature review. I also regressed *NON-COLLAB* on *SCRIPT*[14]. I expected the coefficient of *SCRIPT* to be negative as scripted students are expected to have fewer non-collaborative socio-cognitive processes compared to unscripted students.

RQ2: To what extent, if at all, is task convergence affected by collaborative interaction processes? Can the source of the effect be attributed to collaboration/interaction?

[14] I conducted regression analyses of *COLLAB* on *SCRIPT* and *NON-COLLAB* on *SCRIPT* twice. In the first set of analyses, I used measures of *COLLAB* and *NON-COLLAB* that were obtained from session one chat-logs. In the second set of analyses, I used the corresponding measures obtained from session two chat-logs.

I conducted two regression analyses by fitting *COLLAB* as the predictor in both analyses with *ELEMENT* as the dependent variable in one analysis and *STATEMENT* in the other. I interpreted the coefficient of *COLLAB*, expecting this coefficient in both regression analyses to be positive, aligned with my hypotheses and findings from literature review.

To examine whether task convergence can be attributed to collaboration/interaction, I conducted two post-hoc nominal dyad analyses, with one using the experimental group and the other using the control group. In both analyses, I formed post-hoc nominal dyads by randomly pairing students who had not collaborated during the group tasks. I conducted t-tests to compare *ELEMENT* and *STATEMENT* between real (i.e., students who actually collaborated) and nominal dyads. In each of the two post-hoc nominal dyad analyses, I expected both *ELEMENT* and *STATEMENT* to be higher for real than nominal dyads, aligned with my hypothesis and findings from literature review.

RQ3: To what extent, if at all, are group performances affected by task convergence?

I conducted two regression analyses using *PERFORMANCE* as the dependent variable, with *ELEMENT* as the predictor in one analysis and *STATEMENT* as the predictor in the other. In both analyses, I interpreted the coefficients of *ELEMENT* and *STATEMENT*. I expected them to be positive, aligned with my hypotheses and findings from literature review.

3.7 Summary

The research questions, their corresponding hypotheses, and the research design, which aims to seek answers to the questions, are described in this chapter. This

dissertation study uses a randomized experimental design with carefully selected statistical tests to address those questions. Students were randomly paired to form dyads, and each dyad was randomly assigned to either the experimental or control group. Dyads in the experimental group used a social script to aid their interactions, whereas dyads in the control group were not given any script and were allowed to interact freely.

Prior to the statistical analyses, the socio-cognitive conflict style coding scheme, which is capable of identifying a comprehensive range of socio-cognitive processes, was further validated. This large-scale validation of the reliability of the socio-cognitive conflict style coding scheme involved a rater and me testing the coding scheme on samples of transcripts obtained from this study. I obtained the inter-rater reliability indices of percent agreement and Cohen's kappa, before and after negotiation with the other rater over our coding results. These indices provided a robust understanding of the inter-rater reliability for the coding scheme to better inform researchers of the coding scheme's reliability.

This study contains three research questions. Addressing each of these questions involved using regression analyses to determine the extent in which: (1) interaction processes are affected by a collaborative socio-cognitive process script (with versus without); (2) task convergence is affected by collaborative interaction processes; and (3) group performances are affected by task convergence. Addressing research question two also involved conducting t-tests to compare measures of knowledge convergence between real and nominal dyads. Based on the research design described in this chapter, I present the results of the data analyses that address the research questions in the next chapter.

CHAPTER 4

DATA ANALYSIS

Based on the specific research questions and design described in Chapter 3, I now present the results of the data analyses that address those research questions in this chapter. In the sections that follow, I present the: (1) validation of reliability of the socio-cognitive conflict style coding scheme; (2) data inspection; (3) effectiveness check of random assignment of participants; (4) descriptive statistics of the measures in this study; and (5) results of data analyses that address the research questions.

4.1 Validation of Reliability of Socio-cognitive Conflict Style Coding Scheme

Prior to analyzing the data, I conducted a validation of the reliability of the socio-cognitive conflict style coding scheme. In this study, it is critical to have a valid coding scheme that shows evidence of reliability and is capable of identifying a comprehensive range of functional conversational moves that represent the observable form of socio-cognitive processes inherent in interactions. Although a validation process was incorporated in the development of the coding scheme in my doctoral qualifying paper, the affordances of larger samples of chat-logs involving numerous dyads in this current study provided an opportunity to conduct a larger-scale validation of the reliability of the coding scheme. In general, four modifications were made to the coding scheme to better reflect a comprehensive range of functional conversational moves. Also, the inter-rater reliability indices of the modified coding scheme are acceptable.

4.1.1 Update of Socio-cognitive Conflict Style Coding Scheme

During the application of the coding scheme on the chat-logs obtained in this study, the coding scheme was first updated iteratively to more comprehensively reflect all possible specific functional conversational moves. This iterative process involved raters: (1) identifying patterns in which they faced difficulty assigning utterances into specific conversational moves; (2) discussing among themselves on how to update the coding scheme to overcome each difficulty; and (3) updating the coding scheme accordingly to address each difficulty. Such updating of the coding scheme was not unexpected since numerous samples of chat-logs of different dyads' interactions were used in this study. During the previous development of the original socio-cognitive conflict style coding scheme in my doctoral qualifying paper, the testing of the coding scheme used much smaller samples of chat-logs, which might not contain types of utterances that were present in this study.

Four modifications to the original coding scheme were made to improve the reliability of the coding scheme and allow it to identify a more comprehensive range of functional conversational moves. These changes entailed modifying three existing specific functional conversational moves, namely "passing the buck", "asserting", and "qualifying", as well as adding "sharing" as a new specific collaborative functional conversational move. Details of the four modifications are as follows:

(1) <u>"Passing the buck"</u>. This specific conversational move previously only included asking other members to make decision on what the solution to the task is. Other members could be the group leader, or the person widely acknowledged as the expert of the topic of discussion. The group member refrains from making a

judgment on what is the right solution. However, during the coding of the chat-logs in this study, the raters indicated that several utterances in the chat-logs contained simply "*don't know*" or "*no idea*", and the raters found it difficult to code such utterances into the existing specific conversational moves. Furthermore, for each of such utterances made, the raters could not identify whether the member who made such utterances genuinely did not know or simply did not want to make a decision or provide any opinions. Nevertheless, based on the context of several samples of chat-logs that contained utterances of simply "*don't know*" or "*no idea*", the raters generally agreed that such utterances (i.e., "*don't know*" or "*no idea*") appeared to have a connotation of passing the responsibility to the other group members to carry on the conversation or to make any decisions. As such, to account for such utterances, "passing the buck" was expanded to include simply saying one does not know;

(2) "Asserting". This specific conversational move previously only included insisting on using one's ideas and using one's or other's authority/expertise to get one's way or to make decisions. However, during the coding of the chat-logs in this study, the raters indicated that several utterances contained simply "*let's use my idea*" or "*let's use this*" without explaining the rationale of the decision. Raters found it difficult to code such utterances using the original coding scheme. As such, to account for such utterances, "asserting" was expanded to include rejecting or disagreeing with others' opinions or making judgment without giving reasons. Examples of such a move include "*I don't think your idea works. Let's use mine.*" and "*I don't agree.*";

(3) "Qualifying". This specific conversational move previously only included pointing out complexities in one's or others' ideas. That is, the scope of this definition was clear to raters to enable them to code utterances that indicated a group member's conditional agreement of others' ideas, where some limitations of the ideas were pointed out. However, raters had difficulty coding utterances that indicated a group member's disagreement with other's ideas and where reasons were given to substantiate that member's disagreement. To more clearly account for such disagreements, the specific conversational move "qualifying" was expanded to include disagreeing with others' ideas with reasons given; and

(4) "Sharing". This new specific conversational move is defined as putting forward one's views to start a discussion or when elicited by others. This move was added as a new specific collaborative functional conversational move after raters provided feedback that there were several utterances that reflected group members taking the initiative to share their ideas or who shared their ideas after being requested by others. The raters found it difficult to determine which specific conversational moves for such utterances. After discussion among raters, it was agreed that the initial putting forward of a member's opinions/ideas would be considered "sharing". Subsequent additional information provided by the same member would be considered as "elaborating", which is an existing specific conversational move.

With these modifications, the final version of the socio-cognitive conflict style coding scheme is shown in Appendix O, and this version of the coding scheme was used to obtain the final coding results of the chat-logs in this study.

4.1.2 Inter-rater Reliability

A rater and I applied the resulting coding scheme on numerous samples of chat-logs. Each sample consisted of different interactions involving different dyads, and the total amount of interactions that were randomly selected for this testing of coding scheme was about 10-20% of the total interactions that occurred in this current study. As explained in Chapter 3, I obtained two sets of inter-rater reliability indices to provide a more robust understanding of the inter-rater reliability for the socio-cognitive conflict style coding scheme to better inform researchers of its reliability. Each set consists of two inter-rater reliability indices, namely percent agreement and Cohen's kappa. The first set of inter-rater reliability indices pertain to assigning each utterance into an interaction unit and is similar to segmentation reliability (Strijbos, Martens, Prins, and Jocherns, 2006), where researchers evaluate how reliable the results of the segmentation of the chat-logs into unit of analysis are by different researchers. The second set of inter-rater reliability indices pertain to assigning each interaction unit into one of the specific functional conversational moves in the coding scheme.

The percent agreement of the first and second set of inter-rater reliability indices is 90.3%, and 65.8% respectively, and increased to 95.4% and 84.7% respectively after negotiation between the raters. The corresponding Cohen's kappa is 0.61 and 0.55 respectively before negotiation between the raters, and increased to 0.83 and 0.80 respectively after negotiation. According to Heuvelmans and Sanders (as cited in Veldhuis-Diermanse, 2002), in such analysis, a Cohen's kappa between 0.61 and 0.81 is considered high, whereas a kappa between 0.81 and 1.00 is almost perfect.

4.2 Data Inspection

Prior to data analysis, initial checking and visual inspection of the data (e.g., missing data and possible data entry errors) were conducted. For example, a visual inspection of the data from the post-survey revealed that there were a total of six missing data. These were recoded as "NA" to ensure that the R environment, which was used to conduct the data analysis, recognized these as missing values.

4.3 Check on the Effectiveness of Random Assignment

Before conducting further data analysis, I examined the effectiveness of random assignment of students into control/experimental group by comparing whether the control and experimental groups differ in their group cognition (elements and statements) using students' responses to the pre-survey. Results using t-test revealed that there was no significant difference between the mean levels of the group cognition for both elements ($t(69) = -1.41$; $p = .16$) and statements ($t(69) = 0.02$; $p = .99$). This suggests that the random assignment of students into control/experimental group was effective. There was no evidence to suggest that dyads' shared knowledge of the tasks were different for the control and the experimental group.

4.4 Descriptive Statistics

In Table 4.1, I present the summary descriptive statistics of all the measures used in this study.

Variable	Mean	Median	Standard Deviation (*SD*)	Minimum	Maximum	Inter-quartile Range
COLLAB	19.89	17	12.67	1	54	15.5
NON-COLLAB	3.16	3	2.45	0	12	3
Group cognition (elements) (pre-survey)	2.10	2	1.61	0	6	2
Group cognition (statements) (pre-survey)	0.83	1	1.12	0	6	1
Group Cognition (elements) (post-survey)	6.43	6	4.97	0	24	6
Group cognition (statements) (post-survey)	5.63	4	6.46	0	30	6
ELEMENT	4.37	4	4.70	-2	23	5
STATEMENT	4.83	3	6.08	-2	28	5
PERFORMANCE	10.89	11	1.99	7	16	2.5

Table 4.1. Summary descriptive statistics for 71 dyads on measures on interaction processes, group cognition, and group performance.

As can be seen from Table 4.1, the means of the group cognition measures for both element and statement increased from pre- to post-survey. For example, the mean of group cognition (element) before dyads interacted (i.e., pre-survey) is 2.10 (*SD* = 1.61), whereas the corresponding mean after dyads interacted (i.e., post-survey) is 6.43 (*SD* = 4.97).

Additionally, from Table 4.1, the means of the increases in group cognition for both element and statement before and after dyads interacted are positive. Specifically, the mean of *ELEMENT* is 4.37 (*SD* = 4.70), suggesting that the average increase in the group cognition (element) is 4.37 among all dyads. The mean of *STATEMENT* is 4.83 (*SD* = 6.08), suggesting that the average increase in the group cognition (statement) is 4.83 among all dyads.

Also, the mean score of the group performance is 10.89 (*SD* = 1.99) on a 0-20 points grading system of the submitted group proposal. The worst performing group scored 7 points and the best performing group scored 16 points.

It should be noted that the means of the frequency of collaborative and non-collaborative functional conversational moves in session one during the 30 minutes duration given to dyads to discuss were 19.89 and 3.16 respectively. The magnitudes of these means are probably less than what they really should be for a 30 minutes online discussion. This is because many students initially spent some time chit-chatting with their partners on topics unrelated to the task given (e.g., finding out the identity of their partners) and did not engage in discussing the task at home. This led to the initial part of the chat-logs of several dyads not being related to the task, and these were filtered out and not used for coding. If students had spent less time off-task, the means of the frequency of both collaborative and non-collaborative functional conversational moves would be higher.

4.5 Research Question One

RQ1: To what extent, if at all, are interaction processes affected by a collaborative socio-cognitive process script (with versus without)?

Prior to addressing research question one, I compared the means of *PERFORMANCE* for the experimental and control groups using a two sample t-test to check whether students in the experimental and control groups performed differently. The means of *PERFORMANCE* are 12.1 and 9.6 for the experimental and control group respectively, and the difference between the two means is statistically significant at the

0.05 level ($t(69) = 6.97$, $p < .001$). As such, I conclude that the *SCRIPT* has an effect on *PERFORMANCE*, an ultimate outcome of collaborative learning.

Results of linear regression analyses to address research question one provided evidence that there is an effect of the collaborative socio-cognitive process script on socio-cognitive processes.

Variable	***COLLAB***	***NON-COLLAB***
Session one (n=71 dyads)		
Intercept	12.06***	2.63***
	(1.70)	(0.41)
SCRIPT	15.44***	1.04^^
	(2.39)	(0.57)
R^2	.38	.05
F-statistics	41.74	3.28
df	1,69	1,69
Session two (n=61 dyads[15])		
Intercept	23.31***	7.10***
	(1.66)	(0.84)
SCRIPT	12.50***	1.02^
	(2.29)	(1.16)
R^2	.33	.01
F-statistics	29.70	0.77
df	1,59	1,59

*** $p < .001$; ** $p < .01$; * $p < .05$; ^^ $p = .07$; ^ $p = .38$.

Table 4.2. Regression coefficients (and their standard errors) of regressions of: (a) *COLLAB* on *SCRIPT*; and (b) *NON-COLLAB* on *SCRIPT* using data from sessions one and two of the study.

[15] The attrition was due to 10 students (4 from experimental group and 6 from control group) who were absent in session two. Rather than due to some systemic unobserved factors that could potentially pose threats to the validity of the findings, it is likely that the absentees occurred randomly. First, the number of absentees from the experimental and control group was approximately the same and thus did not provide compelling evidence that the random assignment of students into the two groups was violated. Furthermore, attendance was taken to ensure that students were at their assigned computer laboratory and thus in their pre-assigned group (i.e., experimental or control). Second, the reasons given by students and the school for the 10 absentees did not provide any evidence of systemic factors. One absent student requested to be excused as he had to attend to an important school activity. The principal indicated that the other students were absent from school the whole day and were possibly sick. There were no reasons to believe these students deliberately absent themselves from school the whole day (7:30am to 3:40pm) so as not to participate in session two of my study, which was scheduled to replace the last hour of their official school lessons. Besides, students could just contact me directly (call or text me) to indicate they wanted to drop out of session two without letting their school know. Furthermore, during students' school lessons just before session two commenced, the principal personally briefed and reminded students about attending session two. No students indicated they wanted to drop out of session two even though they were given a chance to indicate so and were assured that there were no consequences of dropping out.

Using dyads' interactions in session one of this study, from Table 4.2, the coefficient of *SCRIPT* in the regression analyses of *COLLAB* on *SCRIPT* is positive at 15.44 (with a standard error (*SE*) of 2.39) and is statistically significant at the 0.05 level ($t(69) = 6.46$, $p < .001$). This suggests that the use of the collaborative socio-cognitive process script in scaffolding dyads' interactions increased the number of collaborative functional conversational moves that represent collaborative socio-cognitive processes inherent in interactions. The number of collaborative functional conversational moves increased by 15.44, on average, when dyads used the collaborative socio-cognitive process script as compared to when dyads interacted freely.

As for the regression analyses of *NON-COLLAB* on *SCRIPT* using chat-logs from session one of this study, from Table 4.2, the coefficient of *SCRIPT* is positive at 1.04 (with a standard error (*SE*) of 0.57). Although this coefficient is not statistically significant at the 0.05 level, it is statistically significant at the 0.10 level ($t(69) = 1.81$, $p = .07$). Together with the fact that 1.04 is close to 0 and that typical interactions between members of dyads consist of substantially more than just one utterance, I conclude that there was no difference in the number of non-collaborative functional conversational moves between dyads who used the script and dyads who did not use the script.

Similar results were also obtained using chat-logs from the second session. The second session provided a larger set of data as compared to session one, since more time was given for dyads to interact in session two (50 min versus 30 min in session one). As seen from Table 4.2 for the session two data, the coefficient of *SCRIPT* in the regression analyses of *COLLAB* on *SCRIPT* is positive at 12.50 ($SE = 2.29$) and is statistically significant at the 0.05 level ($t(59) = 5.45$, $p < .001$). This provided further evidence that

the use of the collaborative socio-cognitive process script in scaffolding dyads' interactions increased the number of collaborative functional conversational moves. Also, as similar to the case of using chat-logs from session one, there is no difference in the number of non-collaborative functional conversational moves between dyads who used the script and dyads who did not use the script ($t(59) = 0.88$, $p = .38$).

It should be noted that residual analyses for both regressions provided no evidence of violation of the normality assumption. The normal probability plot indicated that the majority of the standardized residuals generally followed their theoretical values even though residuals at the extreme ends (i.e., a few of the largest and smallest residuals) seemed to deviate from their theoretical values.

4.6 Research Question Two

RQ2: To what extent, if at all, is task convergence affected by collaborative interaction processes? Can the source of the effect be attributed to collaboration/interaction?

Results of linear regression analyses to address research question two provided evidence that the frequency of collaborative functional conversational moves is positively related to the increase in both the number of similar elements and statements members had in common after dyads' interactions. In Table 4.3, I present the results of the regression analyses of: (a) *ELEMENT* on *COLLAB*; and (b) *STATEMENT* on *COLLAB*. It should be noted that in addressing research question two, strictly chat-logs from session one were used in the data analyses. This was because the focus was to examine whether there was any task convergence immediately after dyads' interactions during that session.

Variable	*ELEMENT* (*n*=65 dyads)	*STATEMENT* (*n*=65 dyads)
COLLAB	0.22***	0.20**
	(0.04)	(0.06)
R^2	.30	.15
F-statistics	26.80	10.77
df	1,63	1,63

*** $p < .001$; ** $p < .01$; * $p < .05$.

Table 4.3. Coefficients of *COLLAB* (and their standard errors) in the regressions of: (a) *ELEMENT* on *COLLAB*; and (b) *STATEMENT* on *COLLAB*.

From Table 4.3, the coefficient of *COLLAB* in the regression analyses of *ELEMENT* on *COLLAB* is positive at 0.22 (*SE* = 0.04) and is statistically significant at the 0.05 level ($t(63) = 5.18$, $p < .001$). This suggests that the increase in the number of elements that members of each dyad had in common after each dyad interacted is positively related to the amount of collaborative functional conversational moves that represent collaborative socio-cognitive processes inherent in interactions. More specifically, the increment in the number of similar elements that members of each dyad had in common increased by 2.2, on average, when the number of collaborative functional conversational moves increased by 10.

Similarly, from Table 4.3, the coefficient of *COLLAB* in the regression analyses of *STATEMENT* on *COLLAB* is positive at 0.20 (*SE* = 0.06) and is statistically significant at the 0.05 level ($t(63) = 3.28$, $p = .002$). This suggests that the increase in the number of statements that members of each dyad had in common after each dyad interacted is positively related to the amount of collaborative functional conversational moves that represent collaborative socio-cognitive processes inherent in interactions. More specifically, the increment in the number of statements that members of each dyad had in common increased by 2.0, on average, when the number of collaborative functional conversational moves increased by 10. Note however that this effect (2.0) is slightly less

than that of the corresponding regression analyses involving *ELEMENT* (which is 2.2). The standard error (0.06) is also higher than that involving *ELEMENT* (which is 0.04), suggesting less precision in the estimates of the coefficients of *COLLAB* in the regression analyses involving *STATEMENT* as compared to *ELEMENT*.

It should be noted that residual analyses showed random scatter of residuals and rather constant error variance in the plot of standardized residuals against *COLLAB*. Therefore, there is no evidence of missing independent variables. However, there were concerns over some outliers (approximately three) that seemed to deviate from the other residuals. On the one hand, some dyads seemed to have rather in-depth discussion of the task with higher frequencies of collaborative conversational moves, but ended up with very different understandings of the strategies they were supposed to have agreed on. On the other hand, some dyads did not interact as much as some other dyads and have lower frequencies of collaborative conversational moves. However, they managed to obtain much higher scores in *ELEMENT* and *STATEMENT* than other dyads. A check with the source data did not reveal any possible reasons (e.g., coding errors) to explain these outliers.

Additionally, residuals at the extreme ends (i.e., a few of the largest and smallest residuals) seemed to deviate from their theoretical values in the normal probability plot, suggesting some possibility of the violation of the normality assumption. Nevertheless, the normal probability plot indicated that the majority of the standardized residuals generally followed their theoretical values. Although the residual analysis results is of secondary importance in this particular research question, since addressing this question is not about identifying the best model to fit the data, readers should keep in mind the

results of residual analyses and exercise caution in interpreting the findings presented in this section.

Post-hoc nominal analysis

Results of the post-hoc nominal analysis shown in Table 4.4 provided evidence that task convergence for both elements and statements can be attributed to collaboration/interaction, regardless of whether dyads were from the experimental or control group.

Variable	***Amount that real exceeded nominal***
Experimental group (n=36 real+36 nominal dyads)	
ELEMENT	6.35***
	(0.97)
STATEMENT	7.00***
	(1.23)
Control group (n=35 real+35 nominal dyads)	
ELEMENT	4.24***
	(0.86)
STATEMENT	3.76***
	(0.91)

*** $p < .001$; ** $p < .01$; * $p < .05$.

Table 4.4. Post-hoc nominal analysis for both experimental and control group.

Elements

The post-hoc nominal analysis revealed that the amounts of task convergence in terms of elements (i.e., *ELEMENT*) for real dyads in both experimental and control groups were greater than that for nominal dyads. These differences were statistically significant at the 0.05 level. As seen from Table 4.4, after real dyads in the experimental group interacted with their partners, the amount of increase in similar elements that they have before and after interaction is 6.35 ($SE = 0.97$), on average, higher than that of nominal dyads ($t(60) = 6.55$), $p < .001$). Similarly for the control group, after real dyads interacted with their partners, the amount of increase in similar elements that they have

before and after interaction is 4.24 (SE = 0.86), on average, higher than that of nominal dyads ($t(66) = 4.94$, $p < .001$).

Statements

The amounts of task convergence in terms of statements (i.e., *STATEMENT*) for real dyads in both experimental and control groups were also greater than that for nominal dyads. These differences were statistically significant at the 0.05 level. As seen from Table 4.4, after real dyads in the experimental group interacted with their partners, the amount of increase in similar statements that they have before and after interaction is 7.00 (SE = 1.23), on average, higher than that of nominal dyads ($t(60) = 5.68$, $p < .001$). Similarly for the control group, after real dyads interacted with their partners, the amount of increase in similar statements that real dyads have before and after interaction is 3.76 (SE = 0.91), on average, higher than that of nominal dyads ($t(66) = 4.12$, $p < .001$).

4.7 Research Question Three

RQ3: To what extent, if at all, are group performances affected by task convergence?

Results of linear regression analyses to address research question two provided evidence that the increase in the number of similar elements members had in common after dyads' interaction is positively related to dyads' scores in their group proposals. However, there is no evidence to suggest any corresponding effect for the number of similar statements members had in common after dyads' interaction. In Table 4.5, I present the results of the regression analyses of: (a) *PERFORMANCE* on *ELEMENT*; and (b) *PERFORMANCE* on *STATEMENT*.

Variable	***Regression analysis (a)*** (n=65 dyads[16])	***Regression analysis (b)*** (n=65 dyads)
Intercept	10.19***	10.48***
	(0.33)	(0.31)
ELEMENT	0.13*	
	(0.05)	
STATEMENT		0.05^
		(0.04)
R^2	.09	.03
F-statistics	6.04	1.76
df	1,63	1,63

*** $p < .001$; ** $p < .01$; * $p < .05$; ^ $p = .19$.

Table 4.5. Coefficients of *ELEMENT and STATEMENT* (and their standard errors) in two separate regressions of: (a) *PERFORMANCE* on *ELEMENT*; and (b) *PERFORMANCE* on *STATEMENT*.

From Table 4.5, the coefficient of *ELEMENT* in the regression analyses of *PERFORMANCE* on *ELEMENT* is positive at 0.13 (SE = 0.05) and is statistically significant at the 0.05 level ($t(63) = 2.46$, $p = .02$). This suggests that the scores of dyads' group proposals are positively related to the increase in the number of elements that members of each dyad had in common after members interacted with their partners. More specifically, the scores of dyads' group proposals increased by 1.3 points, on average, for every 10 increments in the number of similar elements that members of each dyad had in common after they interacted.

Unlike *ELEMENT*, *STATEMENT* did not have any effects on *PERFORMANCE*. From Table 4.5, the coefficient of *STATEMENT* in the regression analyses of *PERFORMANCE* on *STATEMENT* is almost close to zero at 0.05 (SE = 0.04) and is not statistically significant at the 0.05 level ($t(63) = 1.33$, $p = .19$). There is no evidence to suggest that the scores of dyads' group proposals are related to the increase in the number

[16] Students, whose partners were absent, worked on the group proposal on their own. There were also unexplained missing data even though those students were present.

of statements that members of each dyad had in common after members interacted with their partners.

However, as in the case of the regression analyses involving *ELEMENT* and *STATEMENT* in research question two, the residual analyses revealed some issues of concern that readers should keep in mind as they interpret the findings to address this research question. Again, it should be noted that although residual analyses for both regression analyses in research question three showed random scatter of residuals and rather constant error variance in the plot of standardized residuals against *ELEMENT/STATEMENT*, there were concerns over some outliers (approximately one to three) that seemed to deviate slightly from the other residuals. On the one hand, two particular dyads performed extremely well (within the top 8 scores) even though they seemed to have relatively much fewer shared understandings of the strategies they were supposed to have agreed on, as compared to dyads with similar scores in the group proposals. On the other hand, one dyad (call it dyad 53) performed badly even though the dyad obtained one of the highest scores in *ELEMENT* and *STATEMENT*. Although a check with the source data did not reveal any possible reasons (e.g., coding errors) to explain these outliers, it should be noted that, unlike almost all other dyads, dyad 53 seemed to copy and paste their individual responses to the post-survey, such that many of their sentences in the post-survey were identical word for word. This resulted in dyad 53's unusually high scores in *ELEMENT* and *STATEMENT*.

The normal probability plots for both regression analyses indicated that the majority of the standardized residuals generally followed their theoretical values. Although some residuals seemed to deviate from their theoretical values, most tended to

follow their theoretical values, providing no strong evidence of violation of the normality assumption. As they interpret the findings presented in this section, readers should keep in mind that some residuals seemed to deviate from their theoretical values.

4.8 Additional Exploratory Analyses

These issues involving *ELEMENT* and *STATEMENT*, as well as the findings of rather weak or no statistically significant effects observed in research question two and three that involved *ELEMENT* or *STATEMENT* in analyses, led me to query how *COLLAB* directly relate to *PERFORMANCE* without involving *ELEMENT* or *STATEMENT*. To examine this, I regressed *PERFORMANCE* on *COLLAB* in two analyses, one using chat-logs from session one and the other using chat-logs from session two to obtain measures of *COLLAB*. In general, results of the regression analyses revealed that the scores of dyads' group proposals are positively related to the frequency of collaborative functional conversational moves, regardless of whether chat-logs from session one or two were used in the data analyses. In Table 4.6, I present the results of the two regression analyses.

Variable	***PERFORMANCE***
Session one (n=71 dyads)	
Intercept	9.28 ***
	(0.38)
COLLAB	0.08***
	(0.02)
R^2	.26
F-statistics	24.66
df	1,69
Session two (n=61 dyads)	
Intercept	7.51***
	(0.58)
COLLAB	0.12***
	(0.02)
R^2	.41
F-statistics	41.18
df	1,59

*** $p < .001$; ** $p < .01$; * $p < .05$.

Table 4.6. Regression coefficients (and their standard errors) of regressions of *PERFORMANCE* on *COLLAB* using chat-logs from: (a) session one; and (b) session two to obtain measures of *COLLAB*.

From Table 4.6, using chat-logs from session one to obtain measures of *COLLAB*, the coefficient of *COLLAB* in the regression analyses of *PERFORMANCE* on *COLLAB* is positive at 0.08 ($SE = 0.02$) and is statistically significant at the 0.05 level ($t(69) = 4.97$, $p < .001$). This suggests that the scores of dyads' group proposals are positively related to the number of collaborative functional conversational moves that represent collaborative socio-cognitive processes inherent in interactions. The scores of dyads' group proposals increased by 0.8 points, on average, when the number of collaborative functional conversational moves in dyads' interactions increased by 10.

The positive effect of *COLLAB* was even stronger when chat-logs from session two were used to obtain measures of *COLLAB*. As seen from Table 4.6, the coefficient of *COLLAB* in the regression analyses of *PERFORMANCE* on *COLLAB* increased from 0.08 to 0.12 ($SE = 0.02$). This effect was also statistically significant at the 0.05 level

($t(59) = 6.42$, $p < .001$). The scores of dyads' group proposals increased by 1.2 points, on average, when the number of collaborative functional conversational moves in the dyads' interactions increased by 10.

In both regression analyses, the residual analyses did not reveal any serious issues of concern, except for some outliers. The normal probability plots for both regression analyses indicated that the majority of the standardized residuals generally followed their theoretical values. As such, there is no strong evidence to indicate departure from the normality assumption. Also, the plots of standardized residuals against *COLLAB* revealed random scatter of residuals and rather constant error variance, suggesting no evidence of missing independent variables.

4.9 Summary

In summary, I made four key modifications to the socio-cognitive conflict style coding scheme after the coding scheme was applied to the large sample of chat-logs available in this study. I made these modifications to more accurately and comprehensively reflect the possible functional conversational moves. Three of the four modifications involved expanding the scope of definitions of existing conversational moves, namely "passing the buck", "asserting", and "qualifying" to include more types of utterances. For example, utterances simply stating "*don't know*" or "*no idea*" were categorized under "passing the buck" after raters agreed that such utterances seemed to have a connotation of passing the responsibility to other group members to carry on the conversation or make any decisions.

The fourth modification involved adding a new specific collaborative functional conversational move, called "sharing" to address the deficiency of the coding scheme to

account for group members' initiative to share their ideas regardless of whether they were requested or not by others. The initial putting forward of a member's opinions/ideas would be considered "sharing", whereas subsequent additional information provided by the same member on the same opinion/idea would be considered as "elaborating". The final version of the coding scheme displayed reasonable inter-rater reliability.

Findings of the data analyses suggest that the collaborative socio-cognitive process script can be used to generate interactions containing collaborative functional conversational moves that represent collaborative socio-cognitive processes inherent in interactions. However, there is no evidence to suggest that the script affected the amount of non-collaborative functional conversational moves.

Additionally, the frequency of collaborative functional conversational moves that represent collaborative socio-cognitive processes inherent in interactions is positively related to the increase in both the number of similar elements and statements members had in common after dyads' interactions. These effects can be attributed to collaboration/interaction. Also, the increase in the number of similar elements members had in common after dyads' interaction is positively related to dyads' scores in their group proposals. However, there is no evidence to suggest any corresponding effect for the number of similar statements members had in common after dyads' interaction. Lastly, regardless of whether chat-logs from session one or two were used in the data analyses, the scores of dyads' group proposals are also positively related to the frequency of collaborative functional conversational moves.

CHAPTER 5

DISCUSSION AND CONCLUSION

Based on the results of data analyses described in Chapter 4, I now present a discussion of the findings for each research question in this final chapter of my dissertation. After which, I conclude my dissertation with a discussion of potential validity threats and implications for instructional practice. In this chapter, where appropriate, I also made recommendations for future research studies.

5.1 Discussion

My study proposed three research questions and their corresponding hypotheses regarding the relationships between task convergence, the functional conversational moves that represent socio-cognitive processes inherent in interactions, and group performance. Using a sample of 142 students, I empirically tested these relationships to address the research questions. Before addressing the research questions, I updated the socio-cognitive conflict style coding scheme to more accurately and comprehensively reflect the possible specific functional conversational moves. I also conducted a t-test to examine whether students in the experimental and control groups performed differently. As expected, students in the experimental group performed better, thereby providing evidence that the use of the collaborative socio-cognitive process script has an effect on group performance.

5.1.1 Research Question One

RQ1: To what extent, if at all, are interaction processes affected by a collaborative socio-cognitive process script (with versus without)?

Regardless of whether chat-logs from session one or two were used in the data analyses, there is a positive effect of the use of the collaborative socio-cognitive process script (i.e., *SCRIPT*) on the frequency of collaborative functional conversational moves that represent collaborative socio-cognitive processes inherent in interactions (i.e., *COLLAB*). Using chat-logs from session one, the frequency of collaborative socio-cognitive processes for dyads who used the script is, on average, 15.44 more than dyads who did not use the script. An increase of this magnitude is large given that the mean of the frequency of collaborative socio-cognitive processes is 19.89. Using chat-logs from session two, the use of the script increased the frequency of collaborative socio-cognitive processes by 12.50, on average. This effect of the collaborative socio-cognitive process script observed is as expected and aligned with findings from previous research studies involving the use of social scripts, which found that scripts induce specific patterns of interactions and facilitate learning outcomes beyond what could be achieved without scripting (e.g., Weinberger, Stegmann, Fischer, and Mandl, 2007).

It can be noted that the magnitude of the increase dropped slightly from 15.44 to 12.50 when chat-logs from session two were used instead of chat-logs from session one. This is despite the fact that more time was given to students to interact in session two (50 minutes in session two versus 30 minutes in session one). This finding is not surprising as the lecture given to students to teach them the use of collaborative conversational moves was in session one, and the lecture immediately preceded the activity involving dyads'

interactions. With the concepts and the importance of the collaborative functional conversational moves still in students' recent memory, students might be able to use the collaborative functional conversational moves more easily in session one as compared to session two. Unlike in session one, session two, which took place approximately two weeks later, immediately allowed students to interact without any lecture given to help students recall the collaborative functional conversational moves. Thus, despite reminders given constantly during any dyads' interactions in both sessions one and two to encourage students in the experimental group to use collaborative functional conversational moves, it is not surprising that the use of collaborative functional conversational moves decreased in the second session.

Contrary to my expectation, there is no effect of the use of the collaborative socio-cognitive process script (i.e., *SCRIPT*) on the frequency of non-collaborative functional conversational moves that represent non-collaborative socio-cognitive processes inherent in interactions (i.e., *NON-COLLAB*). This finding holds regardless of which data (chat-logs from session one or two) was used. Even though the coefficient of *SCRIPT* is statistically significant at the 0.1 but not the 0.05 level when chat-logs from session one was used, the magnitude is very small at 1.04, suggesting no effect of *SCRIPT* on *NON-COLLAB*. This finding is different from my hypothesis where I expected dyads in the control group to use more non-collaborative functional conversational moves compared to dyads in the experimental group. Furthermore, contrary to what I had expected, more non-collaborative conversational moves were observed in the experimental group. The frequency of non-collaborative conversational moves did not decrease even though the number of collaborative conversational moves increased for the experimental group.

This finding might not mean a deficiency in the script in decreasing the frequency of non-collaborative functional conversational moves. Rather, it could point to the success of the script in creating in-depth and meaningful discussions containing more decision-making occasions that were generated by collaborative conversational moves. In reality, the script could have successfully encouraged students to use more collaborative conversational moves and decreased the frequency of non-collaborative conversational moves. However, this decrease could be overly compensated in the opposite direction by an increase in the number of decisions and ideas that dyads need to agree on. Interactions with in-depth discussions arising from an increase in collaborative conversational moves could result in relatively more decisions and ideas that dyads need to agree on. This resulted in members having to state utterances to indicate their agreement. More often than not, members simply stated utterances such as "*ok*" and "*good idea*", without any collaborative conversational moves (e.g., elaborating, clarifying, extending). Simply agreeing is considered "acquiescing", a non-collaborative conversational move, in the coding scheme. Thus, the increase in acquiescing with members on a larger number of decisions/ideas could have artificially inflated the frequency of non-collaborative conversational moves. Some evidence to support this line of reasoning can be provided by a two sample t-test using chat-logs from session one[17] to examine whether the frequency of acquiescing with members differ for dyads in the experimental and control groups. The frequency of acquiescing with members made by dyads in the experimental

[17] It is appropriate to use only chat-logs from session one in the analyses since all the guiding questions given to scaffold students in their interactions in session one required students to engage in discussions. By contrast, it is not appropriate to use chat-logs from session two in the analyses since the group proposal template given to guide students in their interactions during session two included two guiding questions (out of a total of four questions) that required students to simply recall information/ideas that they had already agreed upon in session one, rather than engage in discussions. It is reasonable to expect the frequency and percentage of non-collaborative functional conversational moves to be higher as compared to when all guiding questions required students to engage in discussions.

and control group are, on average, 2.78 and 1.80 respectively, and the difference between these two frequencies is statistically significant at the 0.05 level ($t(69) = 2.04$, $p = .045$). Furthermore, the percentages of collaborative functional conversational moves[18] made by dyads in the experimental and control groups differ. The percentage of collaborative moves made by dyads in the experimental and control group are, on average, 88.3% and 82.0% respectively, and the difference between these two percentages is statistically significant at the 0.05 level ($t(69) = 2.63$, $p = .01$). Even though the frequency of non-collaborative moves is not affected by whether dyads used the script or not, dyads using the script had utterances that contained a relatively higher proportion of collaborative over non-collaborative moves as compared to dyads who interacted freely.

5.1.2 Research Question Two

RQ2: To what extent, if at all, is task convergence affected by collaborative interaction processes? Can the source of the effect be attributed to collaboration/interaction?

The frequency of collaborative functional conversational moves that represent collaborative socio-cognitive processes inherent in interactions has a positive effect on the increase in the number of both elements and statements that members of each dyad had in common after each dyad interacted. As compared to the case of statements, the magnitude of its effect on elements is slightly higher (0.22 versus 0.20) and more precise with a lower standard error (0.04 versus 0.06).

Although these findings aligned with my hypotheses, the magnitudes of these effects seem rather small. The increment in the number of similar elements (or statement) that members of each dyad had in common increased by only 2.2 (or 2.0 for statement),

[18] A comparison using non-collaborative conversational moves will yield identical results since the percentage of non-collaborative conversational moves is simply 100% minus the percentage of collaborative conversational moves.

on average, when the number of collaborative functional conversational moves increased by 10. In this sample, the mean of the frequency of collaborative functional conversational moves is only 19.73 (Table 4.1).

Although the findings of rather small magnitude of effects in this study follow similar findings by Fischer and Mandl (2005) and Jeong and Chi (2007), there remains a discrepancy between the impression of strong convergence assumed in the literature and the results of this study. As highlighted by Jeong and Chi (2007), this discrepancy could have occurred for several reasons. First, many previous studies (e.g., Roschelle, 1992) estimated knowledge convergence based on students' conversation alone, which might result in a higher level of knowledge convergence. This is because, if knowledge convergence was solely measured based on what students seemed to agree during conversations, many dyads would probably obtain a high level of knowledge convergence. What students appeared to agree on might not necessarily be shared knowledge. For example, students might indicate agreement with their partners' ideas/points (e.g., simply say ok to partners' ideas/points) because they did not want their partners to know that they did not understand the ideas/points presented by their partners. Students might also indicate agreement because they did not want to embarrass their partners by challenging them.

Second, it is important to note that divergent processes could also be occurring, rather than only strictly convergent processes. In fact, as similar to other studies like Jeong and Chi (2007), there are rare cases where knowledge diverged, rather than converged, for some dyads in this study after members interacted. Although common elements and statements from the pre-survey were a result of coincidence, the fact that

students with some initial degree of similarity of elements and statements ended up with lesser degree of similarity, despite having common learning materials and the opportunity to interact with their partners, suggests that collaborative processes can result in divergence of knowledge, not just convergence. According to Jeong and Chi (2007), divergence could occur for various reasons: (1) Students might pay attention to different parts of the conversations especially when they contribute to varying extents at different parts of their conversations. This differential attention and processing of knowledge could lead students to diverge in their knowledge; and (2) Students might play different roles during their conversations, and this could lead to divergence. Some dyads could unknowingly take up different roles, especially if one partner is from the academically strongest class and the other is from the weakest class. For example, in this sample, some academically stronger students could have unintentionally served as an information analyzer while the academically weaker student could have served as an information collector. Such role assignment could result in students focusing on different aspects during their conversations and thus lead to knowledge divergence. This might also explain why evidence of knowledge convergence was not obtained in tutoring situations (Chi, Siler, & Jeong, 2004; Graesser et al., 1995), which involved assigning students to tutor and tutee roles.

Additionally, it should be noted that the residual analyses suggest caution in interpreting these findings. The several outliers apparent in the plot of standardized residuals against *COLLAB* and the deviation of several residuals at the extreme ends (i.e., a few of the largest and smallest residuals) from their theoretical values in the normal probability plot suggest abnormalities in some of the observations. These abnormalities

could not be explained except for the aforementioned reasons on why some of these dyads experienced divergence. More investigations are needed in future research studies to fully understand the relationship between the frequency of collaborative socio-cognitive processes and the increase in the number of both elements and statements that members of each dyad had in common after each dyad interacted.

Findings from the nominal analyses provided further evidence of the importance of collaboration/interaction. The findings align with my hypotheses and reinforce findings from previous empirical studies (e.g., Jeong and Chi, 2007) that knowledge convergence arose due to collaboration/interaction. This study found that the amounts of task convergence in terms of elements and statements for real dyads in both experimental and control groups were greater than that for nominal dyads. The source of convergence observed in students' knowledge did not arise entirely from the fact that partners who collaborated were provided with the same learning material and/or were exposed to the same learning environment. Rather, the findings provided evidence that convergence resulted from students' interactions with their partners.

5.1.3 Research Question Three

RQ3: To what extent, if at all, are group performances affected by task convergence?

The increment in the number of elements that members of each dyad had in common after each dyad interacted has a positive effect on the performance of the dyad. Nevertheless, given that the group proposals were graded on a 0-20 marking scheme and that *ELEMENT* in this sample ranged from -2 to 23 (as seen from Table 4.1), an increase of an average of 1.3 points in the scores of the group proposal for every 10 increment in *ELEMENT* seemed rather small. The maximum value of *ELEMENT* in this sample was

only 23, and this maximum value corresponded to a predicted increase of only 2.99 points in the scores of the group proposal.

The increment in the number of statements that members of each dyad had in common after each dyad interacted has no effect on the performance of the dyad. This is contrary to my expectation because statements that were common to members should better reflect shared knowledge than elements. Unlike elements, statements attempt to grasp the structure of the knowledge to reflect the meaning of the elements (Carley, 1997; Mohammed et al. 2000). Nevertheless, these findings are similar to Van den Bossche, Gijselaers, Segers, Woltjer, and Kirschner (2011), who reported either similar or relatively smaller effect for statement compared to elements for different indicators of actual group performance and no effect for perceived group performance.

These findings could be a consequence of: (1) the over-arching group task possibly not being as group-worthy as it could ideally have been; and/or (2) the difficulty in measuring *ELEMENT* and *STATEMENT*. For the former, although the over-arching group task was designed to be group-worthy in general, it could ideally have been crafted with features that involve more discipline-based, intellectually important content and that require more interdependency among members and individual accountability. The over-arching real-world problem and some aspects of the tasks (e.g., nature of the group product) were requested by the school that participated in my study. Subject to these constraints, the design of the tasks and procedures were then developed to be as group-worthy as possible. Some students might not have found the content and problem-solving skills meaningful or important. Some could also have relied on themselves to some extent, rather than collaborated extensively with their partners, to carry out the tasks. If

the tasks were not as group-worthy as ideally it should be (i.e., not being strong in some elements of group-worthiness), it might explain the observation of the lack of effects.

As for the latter where the findings could be a consequence of the difficulty in measuring *ELEMENT* and *STATEMENT*, the analyses involving these measures of task convergence produced several abnormal observations. Just as in research question two, those abnormalities were highlighted in residual analyses. These abnormality issues could be exacerbated by the difficulty in measuring *ELEMENT* and particularly *STATEMENT*. It is difficult to measure the extent of knowledge convergence in a clear-cut manner, with few studies in the learning sciences that have measured knowledge convergence quantitatively (e.g., Fischer and Mandl, 2005; Jeong and Chi, 2007).

For *ELEMENT*, the number of similar elements between members might be partially affected by the length of students' responses to the pre- and post-survey questionnaires, thus adding difficulty to measuring knowledge convergence accurately. Regardless of whether students and their partners shared or did not share the same understanding, it is likely that, the longer the sentences each member wrote, the higher the number of similar elements between members, and vice versa. In some cases, students wrote very short sentences that efficiently answered the survey questions posed, and this could partially contribute to lower number of similar elements between members. For example, a student (call him member one) answered the question of what was the school problem the pair had identified by writing, "*School curriculum time is too long*", which was short and straight to the point. His partner wrote, "*Students feel sleepy in class as lessons start too early and there should only be one cca day for all cca groups*", which is rather long. Analyzing the two responses yielded only one common element, namely

"*too*", between the two members. If member one had used a more superfluous sentence such as "*School curriculum time is too long with lessons starting too early and ending late*" to express his same point, there would be three common elements, namely "*too*", "*lessons*", and "*early*". The key point that member one wanted to convey in his responses to the survey question remained the same, but the number of common elements between the two members increased from one to three.

The difficulty in obtaining accurate quantitative measures of knowledge convergence is exacerbated in the case of *STATEMENT*, which could explain why the effect of *STATEMENT* could not be detected in research question three. To obtain the statements, not only is there a need to first overcome the difficulty in obtaining the elements, there is also the added difficulty in applying Carley's method on the elements to obtain the relations. Although Carley (1997) had indicated that the reliability and validity of the cognitive mapping method to be satisfactory, there could be an issue of the window size during the windowing process to identify and obtain relations used to obtain *STATEMENT*. While a window of four was used in this study to obtain the relations for the statements, using other window sizes could potentially affect the findings. For example, these were the elements for one of the students' responses: "*No soap keep students hygiene*". The partner's elements were: "*No soap toilets students wash hands hygiene*". If window of two were used, there would only be one statement. If window of three were used, there would be two statements instead. If window of four were used, there would be four statements. If window of five were used, there would still be four statements. However, if window of six were used, there would be five statements. This example illustrates that the difficulty in obtaining *STATEMENT* accurately is exacerbated

since the choice of different window sizes might affect the number of statements, which in turn might affect the findings. More research is needed to investigate the consequences of choices with regard to window sizes (Van den Bossche, Gijselaers, Segers, Woltjer, and Kirschner, 2011; Carley, 1997). Also, future research studies that require the measurement of group cognition could triangulate findings using at least two measurement methods of obtaining group cognition (e.g., using both cognitive mapping and concept mapping) to examine whether the findings are consistent with one another when different measurement methods are used.

5.1.4 Additional Exploratory Analyses

Owing to issues in analyses that involved measures of task convergence (i.e., *ELEMENT* and *STATEMENT*), I conducted additional analyses without involving these measures. I found that, regardless of whether chat-logs from session one or two were used, the scores of dyads' group proposals are positively related to the number of collaborative functional conversational moves that represent collaborative socio-cognitive processes inherent in interactions. The positive effect of *COLLAB* was slightly stronger when chat-logs from session two were used to obtain measures of *COLLAB*.

These findings align with those from previous studies involving interactions (e.g., the use of argumentation in interactions (Asterhan and Schwarz, 2009)), where interaction processes were found to have an effect on various collaborative learning outcomes. More importantly, the finding that slightly greater effect was observed when chat-logs from session two were used provided some evidence of the importance of collaborative interaction processes in group performance. Interactions in session two were meant for students to discuss and finalize their pairs' proposal and took place

immediately before students submit their group proposals, which in turn were graded to obtain measures of group performance. By contrast, interactions from session one were not as directly related to the crafting and finalization of the group proposals as compared to the interactions in session two. The varying degree of connectedness between the group proposals and the interactions from the two sessions is consistent with the differing strength of magnitudes of the effects using chat-logs from session one and two.

5.2 Validity Threats

There are three key validity issues, which I have tried to offset through the methodological strengths of my study. First, since this study consisted of newly formed pairs performing complex tasks with no expectation of future interactions, this raises questions about the generalizability of any findings. My findings will best apply to group-work conducted online with group-worthy tasks pertaining to average ability grade nine students. The tasks were not too simplistic or complex for this sample since they were developed collaboratively with experienced teachers. Furthermore, the issue of validity restricting my findings to online or instant messaging platforms and not face-to-face will not be of concern, as more and more schools and students embrace the use of instant messaging technologies to engage in school-related discussions. Instant messaging technologies have already become a popular mode of communication among students (Lenhart, Madden, and Hitlin, 2005). From feedback given by the school and from my observations during the two computer laboratory sessions, students in this sample were familiar and comfortable with using the online chat technology in this study.

Nevertheless, generalizability of any findings should be done with caution and with the range of values of each independent variable taken into consideration. For example,

as explained in Section 4.4, the range of values of *COLLAB* (i.e., 1 to 54) and the magnitudes of the means of *COLLAB* and *NON-COLLAB* in this study are probably lower than what they really should be for a 30 minutes online discussion. The findings should only be interpreted within the range of values of *COLLAB* in this study. It is possible that students will engage in longer school-related online discussions, and their interactions will likely contain higher frequency of collaborative functional conversational moves that exceed the maximum value observed in this study. Hence, there is a need for future studies to investigate whether the relationships found in this study hold using a larger range of values of *COLLAB* and other independent variables.

Second, an accuracy issue pertaining to the analyses of chat-logs could be questioned, thereby compromising the validity of any findings. While efforts had been made to ensure that the coding scheme is valid and shows evidence of reliability, a possible drawback of using the coding scheme is that it might not fully capture socio-cognitive processes that are not apparent from the observed functional conversational moves. This issue especially affects analyses of chat-logs of students guided by the script. The script encourages students to make use of a range of collaborative conversational moves. Some of these moves, such as exploring, qualifying, and synthesizing, inherently require students to engage in higher-order thinking. Thus, it is possible that the presence of the script might have triggered students to think more critically of their partner's ideas/comments. However, students might not write down utterances reflecting collaborative functional conversational moves that inherently require students to engage in higher-order thinking. Instead of typing out utterances containing those collaborative conversational moves associated with higher-order thinking, students might straightaway

share ideas that resulted from these higher-order thinking. For example, some students might not write utterances such as "*based on this and that…*", but instead immediately write utterances sharing new ideas they came up with. While those new ideas might or might not be explicitly related to any ideas or utterances that their partners had written previously in their conversations, those ideas could possibly be triggered by what their partners wrote and could be extensions or syntheses of ideas that were shared earlier. If this were the case, it would be difficult to identify these utterances as synthesizing, extending or qualifying, which are conversational moves that inherently involve higher-order thinking.

This accuracy issue pertaining to the analyses of chat-logs could result in two consequences: (1) The frequency of collaborative conversational moves will be under-reported, especially those from students using the script. This is because several utterances containing those moves might not be explicit enough to be observed in the chat-logs; and (2) The effect of the script on group performance might extend beyond simply increasing the frequency of collaborative conversational moves. Some of the ideas that resulted from higher-order thinking might possibly be of higher quality as compared to ideas that were not developed from higher-order thinking. Thus, the effect of the script could be more than that of the observed collaborative conversational moves themselves. A regression analyses using *SCRIPT* and *COLLAB* as joint independent variables with *PERFORMANCE* as dependent variable supported this reasoning. After accounting for *COLLAB*, there is still an effect of the *SCRIPT* on *PERFORMANCE*. Future research studies should encourage students to make their thinking visible and give as many utterances as possible that align with their thinking processes.

Lastly, issues pertaining to the accuracy and quality of group cognition might be questioned, thereby compromising the validity of any findings. Other measures of group cognition require participants to choose and/or rate the relatedness of pre-determined elements, even if participants might not possess such elements. By contrast, my approach in this study elicited elements and statements from students and thus provided more accurate measures of group cognition. However, this study surfaced additional issues pertaining to these measures in terms of accuracy and quality of group cognition.

Accuracy

Some outliers, which prompted me to further examine possible reasons for their abnormality, led to the discovery of possible accuracy issues regarding these measures. Contrary to the trend observed, a handful of dyads with rather low scores in *PERFORMANCE* had unusually high scores in *ELEMENT* and *STATEMENT*. An examination of the post-survey responses and chat-logs revealed that a handful of students seemed to copy and paste their partners' answers to the guiding questions given in their online discussions. The guiding questions were similar to questions in the pre- and post-survey in order to keep students' online discussions in the right direction. It is possible that these students might have simply copied and pasted answers that their partners shared without understanding what was written and without engaging in any discussions with their partners. Also, their partners might have simply written utterances to share how they intend to answer the guiding questions without discussing with their partners.

These two possible scenarios, coupled with the aforementioned difficulty of measuring *ELEMENT* and particularly *STATEMENT* in Section 5.1.3, could have

contributed to the abnormalities. If a student had copied and pasted a long sentence contributed by his partner without understanding what it really means, the dyad would have gotten an extremely high score in both *ELEMENT* and *STATEMENT*, even if the members did not have shared understanding of the task. As explained in Section 5.1.3, the longer the sentences that were copied and pasted, the higher the scores for *ELEMENT* and *STATEMENT* and thus the higher the degree the severity of the abnormality could be.

On hindsight, I could have planned to prevent students from assessing their chat-log histories while doing the post-survey. However, doing this will not make the online interactions authentic since many chat technologies (e.g., Skype, Facebook chat) allow users to access chat-log histories. Nevertheless, preventing students from having access to chat-log histories could be considered in future research studies that relate to knowledge convergence in collaborative online learning environments. Also, as highlighted earlier in Section 5.1.3, the windowing technique used in Carley's (1997) method could affect the accuracy of these measures of group cognition. More research is needed to investigate the consequences of choices with regard to window sizes (Van den Bossche, Gijselaers, Segers, Woltjer, and Kirschner, 2011; Carley, 1997).

Quality

Simply examining convergence without taking account of the quality of dyads' mental models might yield misleading findings. Convergence of group cognition does not necessarily mean quality (Van den Bossche et al., 2011). Group members may have shared understanding of task strategies, but those strategies could be inappropriate to address the given task.

To assess quality, one approach is to compare each dyad's mental models against experts' models. Since heterogeneous experts' mental models might be available, I could have identified multiple expert mental models by labeling dyads that score among the highest marks in their group proposals as experts. I could then compare each dyad's mental model against each of those experts' models. The smallest difference of all differences found will represent a measure of the quality of the dyad's mental model. This could serve as a possible covariate in the regression analyses of group performance on task convergence. However, doing this turns out to be difficult in this study as there are too many possible school problems that students identified to work on in their group proposals. Some of the dyads chose problems that none of the top performing dyads had chosen, and thus these dyads' mental models could not be fairly compared against any expert mental models. In future research studies, a measure of the quality of the dyad's mental model could be conceptualized to ensure that every dyad/group has a quantitative measure of the quality of its mental model. This measure can then be considered as a possible covariate in the regression analyses of group performance on task convergence.

5.3 Implications for Instructional Practice

Findings from this study hold important implications for the design of collaborative learning activities that leverage socio-cognitive conflicts. Among other factors, in any group-work, I would encourage teachers to provide some form of scaffolding (e.g., through the use of the collaborative socio-cognitive process script) to enhance students' interactions to increase the likelihood that the communication and collaborative learning activities will be productive. Findings from this study have provided empirical evidence that the use of the collaborative socio-cognitive process script can offer a promising way

to facilitate the type of productive communication to make group-work beneficial. It is not sufficient to simply assign group tasks without providing any guidance or scaffolding (Weinberger, Stegmann, and Fischer, 2010).

There is evidence to suggest that the use of the collaborative socio-cognitive process script was able to scaffold students' interactions and facilitated more collaborative functional conversational moves that represent the observable form of collaborative socio-cognitive processes inherent in students' interactions during group-work. Although the use of the script did not result in a decrease in the frequency of non-collaborative functional conversational moves, this finding might not mean a deficiency in the script. It is likely that the use of the script was successful in creating in-depth and meaningful discussions containing more decision-making occasions that were generated by collaborative conversational moves. Furthermore, the effect of the script could extend beyond simply increasing the frequency of collaborative conversational moves. Collaborative functional conversational moves that inherently involve higher-order thinking (e.g., synthesizing, qualifying) might trigger students to think more critically of their partner's ideas/comments and result in higher quality of group performance. Some of the ideas that resulted from higher-order thinking might possibly be of higher quality as compared to ideas that were not developed from higher-order thinking.

Additionally, findings from this study have implications for specific design features of the tasks and procedures in collaborative learning activities. In order to have sufficient frequency of collaborative functional conversational moves to have any substantial knowledge convergence, the following design features of the tasks and procedure might need to be in place:

(1) There needs to be constant encouragement and enforcement to ensure students continue to refer to the script to scaffold their interactions;

(2) The duration given to allow dyads to interact needs to be long enough;

(3) The task needs to be as group-worthy as possible and therefore engaging for students to remain task-oriented to fully utilize the time for online discussion; and

(4) There needs to be constant encouragement and enforcement to ensure students remain task-oriented to fully utilize the online discussion.

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7 APPENDICES

Appendix A: Socio-cognitive Conflict Style Coding Scheme

Main Functional Moves	Specific Functional Moves	Description / Indicators	Examples
Avoiding/Dominating/Compromising/Accommodating conflicts			
Avoiding	Postponing	• Putting off differences in ideas without discussion or giving reasons.	• "Let's skip this first, and move on to the next question."
	Passing the buck	• Asking someone (e.g., leader) to make decision on solution.	• "Brian, we'll follow what you think is right."
Forcing / Competing/ Dominating	Asserting	• Insisting on using one's ideas. • Using one's or others' authority/expertise to get one's way or to make decisions. • Rejecting others' opinions or making judgment without giving reasons.	• "I don't care what you all say, but I am 100% sure that my understanding is correct, and we should use my idea." • "I got the highest in our tests, and so I should be right."; "Let's use Sue's idea because she is smarter than any of us." • "I don't think your idea works. Let's use mine."
	Threatening	• Making threats to force others to comply.	• "One more word and I won't lend you my study notes."
	Justifying	• Providing reasons for one's ideas (e.g., with support from one's experience, textbook, etc.).	• "I am thinking that this should be the right solution because I remembered that there was a similar question with this solution in the textbook."

Main Functional Moves	Specific Functional Moves	Description / Indicators	Examples
Compromising	Voting	• Making decision based on majority of support for a particular idea.	• "How many think this idea is correct?"
	Using social negotiating	• Making decisions based on a purely social basis.	• "We used your ideas last time, so use mine this time."
	Proposing middle ground	• Taking bits of each idea without synthesizing or examining various perspectives.	• "So Roy thinks that the speed of the object increases the longer it falls, but Jay feels that the speed remains constant. Perhaps the speed increases only till a certain point, and then remains constant?"
	Trading off	• Giving up something in return for something else.	• "I'll be willing to use your method if you are willing to let me xxx."
Accommodating	Emphasizing commonalities	• Stressing areas that most/all agree.	• "At least I think all of us agree that one of the factors that affect resistance is the shape of the object."
	Acquiescing	• Giving in to others' opinions without evidence of any collaborative moves (see below).	• "Okay."

Main Functional Moves	Specific Functional Moves	Description / Indicators	Examples
		Embracing conflicts	
Collaborating	Eliciting	• Asking others for opinions. • Seeking help to work out solution.	• "Peter, what do you think of his idea?" • "Sam, do you have any suggestions on how to solve this question?"
	Elaborating	• Providing more details or explanation.	• "I think the force that Mary was referring to is friction. Friction is a force that acts in the opposite direction of motion, and so slows down motion."
	Clarifying	• Verifying other's ideas. • Rephrasing or restating others' or one's views. • Asking others to elaborate.	• "Am I correct to say that you think that xxx?" • "When you say xxx, do you mean yyy?" • "When you say xxx, what do you mean?"
	Extending	• Building directly on others' ideas. • Making Inferences.	• "That would also mean that we have to xxx." • "That would imply that xxx."
	Exploring	• Analyzing implications or consequences. • Comparing ideas. • Testing ideas.	• "Bob's point is xxx. What would happen if we use his idea?" • "If we use John's idea, we would xxx. If we use Joe's idea, we would yyy." • "Let me try out this idea and see how it turns out before we make a decision."
	Qualifying	• Pointing out complexities in one's or others' ideas (e.g., restricting range of application of an idea).	• "Yes, but this idea might not work if xxx."
	Synthesizing	• Linking ideas/interpretations.	• "Your idea and John's earlier point together would mean xxx."

The five main categories of functional moves:

1. Avoiding is associated with sidestepping, or passing-the-buck. When one avoids cognitive conflict, one does not face up to or confront the cognitive dissonance that is generated through one's interaction with others.

2. Forcing/competing/dominating is associated with forcing behaviors to win one's position, where one's own concerns are set above those of other parties in order to attain and/or maintain a higher position (e.g., being seen as right, or being knowledgeable).

3. Compromising is associated with finding a suitable mutually acceptable solution that partially satisfies all parties. It is associated with give-and-take where both parties give up something to come to a mutually acceptable decision.

4. Accommodating is associated with playing down the differences, and emphasizing commonalities. Such a move could involve some self-sacrifice, and is made usually to maintain good relationships.

5. Collaborating is the only one in which the learner embraces the cognitive conflict. There are evidences from the online interactions that the learner confronts and faces up to the cognitive dissonance one is experiencing through one's interaction with others. When collaborating, one tries to work together with other people to find a solution that satisfies the needs of everyone concerned. This style is associated with sharing of ideas, and examination of differences to reach a view acceptable to various parties.

Appendix B: An example of Carley's method

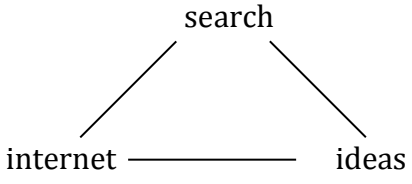
Each sentence in each student's submitted pre- and post-survey is filtered and windowed (the delete/thesaurus list is applied concurrently). The following is an example of how Carley's method is being used to examine shared elements/statements between two students in the same group:

	Student A	**Student B**
Full sentence	Search the internet on ideas on ways to encourage cleanliness in classrooms.	Find ideas on internet.
After filtering	Search internet ideas ways encourage cleanliness classrooms	Find ideas internet.
Windowing (length 4) and applying delete/thesaurus list	"search-internet", "search-ideas", "search-ways", "internet-ideas", "internet-ways", "internet-encourage", "ideas-ways", ideas-encourage", "ideas-cleanliness", "ways-encourage", "ways-cleanliness", "ways-classrooms", "encourage-cleanliness", and "cleanliness-classrooms".	"search-ideas", "search-internet", and "ideas-internet" (since "find" and "search" are considered similar words here).

Final results:

	No. of elements	**No. of statements**
Student A	7	14
Student B	3	3
No. of shared elements/statements	3	3

The shared mental model for these two sentences consists of the three statements: "search-ideas", "search-internet", and "ideas-internet". Repeat the process for all sentences that each pair wrote to obtain all the distinct shared statements, which form the shared mental model.



Appendix C: Collaborative socio-cognitive process script

The following are ways in which group members can interact collaboratively with one another. Members should use as many collaborative moves as possible until a point in which they agree fully with one another.

	Collaborative moves		
Collaborating	Eliciting	• Asking others for opinions. • Seeking help to work out solution.	• "Peter, what do you think of his idea?" • "Sam, do you have any suggestions on how to solve this question?"
	Elaborating	• Providing more details or explanation.	• "I think the force that Mary was referring to is friction. Friction is a force that acts in the opposite direction of motion, and so slows down motion."
	Clarifying	• Verifying other's ideas. • Rephrasing or restating others' or one's views. • Asking others to elaborate.	• "Am I correct to say that you think that xxx?" • "When you say xxx, do you mean yyy?" • "When you say xxx, what do you mean?"
	Extending	• Building directly on others' ideas. • Making Inferences.	• "That would also mean that we would have to xxx." • "That would imply that xxx."
	Exploring	• Analyzing implications or consequences. • Comparing ideas. • Testing ideas.	• "Bob's point is xxx. What would happen if we use his idea?" • "If we use John's idea, we would xxx. If we use Joe's idea, we would yyy." • "Let me try out this idea and see how it turns out before we make a decision."
	Qualifying	• Pointing out complexities in one's or others' ideas (e.g., restricting range of application of an idea).	• "Yes, but this idea might not work if xxx."
	Synthesizing	• Linking ideas/interpretations.	• "Your idea and John's earlier point together would mean xxx."

Appendix D: Parents' consent letter

If you do not wish to participate, fill in your name in this box and return this letter in the envelope provided. Seal the envelope.

Study Title:	Effects of socio-cognitive conflicts on group cognition and group performance
Investigator:	Cheng San Chye (under the supervision of Prof. Christopher Dede, Prof. Hunter Gehlbach, and Dr. Daniel Wilson)

Dear Parent or Guardian:

I write to request your permission for your child to participate in my educational research study. I am a doctoral candidate at the Harvard Graduate School of Education at Harvard University and am undertaking this study for my dissertation. Both Harvard University and the Ministry of Education (Singapore) have given approval for this research study to be carried out. This parental/guardian consent letter includes the information about the study.

Participation is voluntary
You can decide whether or not to permit your child to participate in this research. Activities in this study will not be included as part of students' school assessment. Should you allow your child to participate, there is no need for you to do anything. However, should you decide not to allow your child to participate, please fill in your child's name at the top-right corner of this letter, and ask your child to return this letter in the envelope provided by dropping it in his/her Form Teacher's pigeon hole. If we receive this letter with your child's name on it, we will not involve your child in this study. The envelope should be sealed so that only I can see. While others are participating in the research activities, your child can be assigned other school-related work/activities by the school.

If you choose to allow him/her to participate, you may change your mind and have him/her leave the study at any time. Refusal to participate or stopping participation will involve no penalty or loss of benefits to which you or your child are otherwise entitled.

What is the purpose of this research?
The larger goal of this research is to examine how teachers can leverage the different perspectives that each student brings to the class in order to improve students' learning. Specifically, this study examines how teachers can help facilitate students to better interact with one another by building on and integrating different students' ideas and perspectives. Such interactions enable students to collaborate and learn more productively during group activities.

How long will my child take part in this research?
All participants will attend two computer-laboratory sessions held on 13 and 25 March 2014, each lasting not more than two hours. In-between the two sessions, participants

will collect data (e.g., search internet, conduct short survey) that they will analyze in the second session to formulate solutions to solve an authentic problem faced by the school.

What can I expect if my child takes part in this research?
During the first computer-laboratory session, participants will be familiarized with problem-solving skills. Each participant will be randomly paired with another student. While all participants will be made aware a comprehensive range of ways of interacting in an online group discussion, some pairs will be randomly chosen and requested to interact using specific ways that we think can enhance interactions. The remaining pairs will be allowed to interact freely. Each pair will then be presented an authentic problem faced by their school. Using an online platform, each pair will discuss and brainstorm strategies on how to obtain data that they can use to formulate solutions to that problem.
Prior to the second session, each student will attempt to obtain the data that his/her pair decided to collect. During the second session, each pair will analyze the data, discuss findings, and submit a proposal on how to address the problem faced by their school.

What are the risks and possible discomforts?
There are no risk or possible discomforts. The way the sessions will be carried out is similar to how lessons are typically conducted in Singapore schools.

Are there any benefits from being in this research study?
While we cannot promise any benefits to you or your child from being in this research study, possible benefits include reinforcing and enhancing your child's problem-solving skills. Also, your child can become aware of how he/she can interact collaboratively with others to maximize his/her learning. All these skills can help your child do well in both studies and future work-life. Additionally, by allowing researchers to examine how teachers can facilitate collaborative learning activities, your child's participation will also allow him/her to make valuable contribution to improving the quality of teaching and learning in schools.

Will there be compensation for participating in this research?
Three best pairs from those who are allowed to interact freely and three best pairs from those who are requested to interact using specific ways will each receive a $5 Popular bookstore voucher. The best pairs are selected based on their score on the quality of their submitted group proposal.

If my child takes part in this research, how will our privacy be protected? What happens to the information you collect?
The data we collect will be kept in a password-protected computer and can only be identified using students' unique identification number. A separate document that links the names of the participants and their identification numbers will be stored at another password-protected computer.

Only questions related to the tasks given to students in the two sessions will be asked via a pre- and post-survey questionnaire. Those questions are necessary for the research. No sensitive questions about the participants will be asked. Also, online interactions required of the participants during the two sessions will only be related to the given tasks.

If I have any questions, concerns or complaints about this research study, who can I talk to?

The researcher for this study is Cheng San Chye who can be reached at 62415412 or san_chye_cheng@mail.harvard.edu for any of the following:

- If you have questions, concerns, or complaints,
- If you would like to talk to the research team,
- If you think the research has harmed your child, or
- If you wish to withdraw your child from the study.

This research has been reviewed by the Committee on the Use of Human Subjects in Research at Harvard University. They can be reached at 617-496-2847, 1414 Massachusetts Avenue, Second Floor, Cambridge, MA 02138, USA, or cuhs@fas.harvard.edu for any of the following:

- If your questions, concerns, or complaints are not being answered by the research team,
- If you cannot reach the research team,
- If you want to talk to someone besides the research team, or
- If you have questions about your or your child's rights as a research participant

Appendix E: Students' assent letter

If you do not wish to participate, fill in your name in this box and return this letter in the envelope provided. Seal the envelope.

Study Title: Effects of socio-cognitive conflicts on group cognition and group performance

Investigator: Cheng San Chye (under the supervision of Prof. Christopher Dede, Prof. Hunter Gehlbach, and Dr. Daniel Wilson)

Dear Student:

My name is Mr Cheng San Chye. I am a doctoral candidate at the Harvard Graduate School of Education at Harvard University. I am trying to learn more about how teachers can help students interact with one another to enable students to learn better in a group. Examining this can help teachers develop lessons that leverage the different perspectives that each student brings to the class. To do this, I am asking you and other students to take part in my research study. A research study is a way to learn more about something. Both Harvard University and the Ministry of Education (Singapore) have given approval for this research study to be carried out.

What can I expect during the study?

If you decide you want to be in my study, I will ask you to be involved in the following over the course of two computer-laboratory sessions held on 13 and 25 March 2014, each lasting not more than two hours:

Session 1

During the first session, you will be familiarized with problem-solving skills, and be randomly paired with another student. While all participants will be taught a comprehensive range of ways of interacting in an online group discussion, some pairs will be randomly chosen and requested to interact using specific ways. The remaining pairs will be allowed to interact freely using any of those taught ways of interacting. Each pair will be introduced to a real problem that your school is facing. Using an online platform, your pair will discuss and brainstorm strategies on how to obtain data that your pair can use to come up with solutions to the problem your school is facing.

Prior to session 2, you will need to obtain the data that your group decided to collect.

Session 2

During the second session, your pair will analyze the data, discuss findings, and submit a proposal on how to address the problem. Researchers will reinforce some ways of interaction that are collaborative and that could

Being in this study will not hurt you. Other people will not know if you are in my study. The information I write down about you and other students will be kept safely locked up. When I tell other people or write an article about my research, I will not use your name.

Instead, being in this study can potentially benefit you. You will learn important skills such as interaction and problem-solving skills. Also, three best pairs from those who are allowed to interact freely and three best pairs from those who are requested to interact using specific ways will each receive a $5 Popular bookstore voucher. The best pairs are selected based on their score on the quality of their submitted group proposal.

Your parent or guardian has to say it is OK for you to be in the study. After they decide, you get to choose if you want to do it or not. Before you decide, I will answer any questions you may have. You can also talk to your mom or dad.

You do not have to be in this study. It is okay if you decide you do not want to be in the study or if you change your mind and wish to stop at any time. No one will be mad at you. The activities in this study will not be included as part of your school assessment. You can say no even if your mom or dad (or guardian) say yes.

Should you decide to participate in this study, there is no need for you to do anything. However, should you decide not to participate, please fill in your name at the top-right corner of this letter and return this letter in the envelope provided by dropping it into your Form Teacher's pigeon hole. If we receive this letter with your name on it, we will not involve you in this study. The envelope should be sealed so that only I can see. While others are participating in the research activities, you can be assigned other school-related work/activities by the school.

You can call me at 62415412 if you have questions about the study or if you decide you do not want to be in the study any more.

Appendix F: Notification of exemption determination letter from the Harvard University Committee on the Use of Human Subjects

HARVARD
Human Research Protection Program

Harvard University-Area
Committee on the Use of Human Subjects
1414 Massachusetts Avenue, 2nd Floor
Cambridge, MA 02138
Federal Wide Assurance FWA00004837

Notification of Exemption Determination

January 2, 2014

San Chye Cheng
sac825@mail.harvard.edu

Protocol Title:	Effects of Socio-cognitive Conflicts on Group Cognition and Group Performance
Protocol #:	IRB13-3390
Funding Source:	None
IRB Review Date:	1/2/2014
IRB Review Action:	Exempt

Dear San Chye Cheng:

On 1/2/2014, after review of your submission, the Institutional Review Board (IRB) of the Harvard University-Area determined that the above-referenced protocol meets the criteria for exemption per the regulations found at 45 CFR 46.101(b)(1).

Additional review by the IRB is not required. However, any changes to the protocol that may alter this determination must be submitted for review via a modification (by selecting the create modification/CR activity in the ESTR system) to determine whether the research activity continues to meet the criteria for exemption.

The IRB made the following determination:

- Research Information Security Level: The research is classified, using Harvard's Data Security Policy, as Level 2 Data.

If you have any questions, please contact me at 617-495-1775 or fennever@fas.harvard.edu.

Sincerely,

Fanny Ennever
Senior IRB Administrator

Appendix G: Approval letter from the Ministry of Education (Singapore)

1 North Buona Vista Drive
Singapore 138675
Robinson Road P.O. Box 746
Telephone : (65) 68722220
Facsimile : (65) 67755826
Website : www.moe.gov.sg
Email : muhd_imran_yusof@moe.gov.sg
leong_choi_peng@moe.gov.sg

Ministry of Education
SINGAPORE

EDUN N32-07-005

Request No.: **RQ25-14(02)**

17 February 2014

Mr Cheng San Chye
Blk 132 Bedok North Street 2
#14-83
Singapore 460132

Dear Mr Cheng,

EFFECTS OF SOCIAL COGNITIVE CONFLICTS ON GROUP COGNITION AND GROUP PERFORMANCE

I refer to your application for approval to collect data from schools.

2. I am pleased to inform you that the Ministry has no objections to your request to conduct the research in **1 secondary school**, subjected to the following conditions:

a) the approved research proposal is adhered to during the actual study in the school;
b) the data collected is kept strictly confidential and used for the stated purpose only; and
c) the findings are not published without written approval from the Ministry.

3. When conducting the data collection in the school, please ensure that the following are carried out:

a) consent is obtained from the Principal for the study to be conducted in the school;
b) written parental consent is obtained before conducting the study with the students;
c) students and teachers are informed that participation in the study is voluntary and they do not need to provide any sensitive information (e.g. name and NRIC No.);
d) participation by the school is duly recorded in Annex A; and
e) the data collection in the school is completed within 6 months from the date of this letter.

4. Please show this letter and all the documents included in this mail package (i.e. the application form, research proposal and research instrument(s) marked as seen by MOE) to seek approval from the Principal and during the actual study.

Yours sincerely

Muhamad Imran Bin Mohd Yusof (Mr)
Management Information/Corporate Research Officer
Management Information/Corporate Research
for Permanent Secretary (Education)

Note to Principal: Please refer to MOE notification PA/25/12 for the Guidelines on Data Collection from Schools.

SINGAPORE QUALITY CLASS PEOPLE DEVELOPER SINGAPORE Integrity, the Foundation • People, our Focus • Learning, our Passion • Excellence, our Pursuit

Appendix H: Lesson plan

Level: Secondary Two/Three

Subject: CME

Topic: Clean and conducive classroom environment for teaching and learning

Purpose: Collaboratively problem solve a real-world issue that the school is facing

Description: Students are introduced a simplified problem solving approach, and they apply it to collaboratively address the real-world issue of *"how can a class work together to create a clean and conducive classroom environment for teaching and learning"*.

Pre-lesson Activity: Nil

Duration: Two sessions (Session 1 is 1 hour and 50 min; Session 2 is 1 hour)

Venue: 2 large rooms with projectors and 4 computer laboratories

	Activities	Duration	Resources
	Session 1		

1.	Teacher will provide:
	• an overview of the research study
	• an overview of session 1 and 2
	  o Teacher will introduce the specific real-world problem that the school is facing and explain why addressing this problem is important to the school and students: *"how can a class work together to create a clean and conducive classroom environment for teaching and learning"*.
	• benefits of participating in this study
	  o be aware of ways of interactions (collaborative and non-collaborative)
	  o go through a process of problem-solving
	  o help the school make learning and teaching more conducive and in turn benefit themselves
	  o book vouchers for selected students who do well.
		5 min	

Activities		Duration	Resources
2.	For experimental group: • Teacher will introduce students to both examples of collaborative and non-collaborative interaction skills. • Teacher will emphasize that students should use collaborative moves during any group tasks. For control group: • Teacher will introduce students to both examples of collaborative and non-collaborative interaction skills. • Teacher will emphasize that students can interact freely during any group tasks. For both groups: • Conduct verbal mini-quiz to assess how well they have learnt. Examples of hypothetical interaction chat-logs will be shown to students, and a few students will be randomly selected to ask them to: (1) identify what types of moves are used in those examples, and (2) use one of the specific moves to give a response to the last line of the chat-logs.	25 min	Script

3.	Teacher will provide:
	• an overview of a simplified problem-solving approach
	  o What is the problem and what are possible solutions?
	  o What information and data do we need in order to help us make informed decisions on the solutions?
	  o How can we collect those information and data?
	  o Who can we collect these from?
	  o What is the sample size (if applicable)?
	  o Analyze the information and data (e.g., pie chart, bar chart, mean, mode, median, etc.)
	  o What are the proposed solutions?
		20 min	

Activities		Duration	Resources
4.	Teacher will instruct students to individually come up with strategies that can be used to address the problem, and at the same time, teacher will administer the pre-survey, which students can complete as they think of the strategies.	20 min	Pre-survey questionnaire
5.	Students will work in assigned pairs via an online synchronous chat tool. They share their individual strategies and collaboratively come up with a mutually agreed upon set of strategies that they will use to address the issue. Students will carry out their strategies before session 2.	30 min	Online synchronous chat tool
6.	Teacher will • administer the post-survey, which students will complete **individually**. • remind students that they should carry out the strategies they have come up with their partner to collect any information and data they need prior to session 2. • remind students that they need not communicate with their partners prior to session 2. • Remind students of the benefits of session 2 (e.g., we will teach them a scientifically-proven successful way of interacting, book mark souvenirs, book vouchers to be given for students who do well, school will consider and use best proposals)	10 min	Post-survey questionnaire

	Activities	Duration	Resources
	Session 2		
7.	Teacher will • instruct students to discuss in their same assigned pairs to use the information and data the pairs have collected to come up with concrete action plans to solve the real-world problem that the school is facing. • remind students to refer to the rubric in their discussions. • stress to students that the school values their suggestions and will implement those that are suitable. <Note: For the experimental group, teacher will remind students to refer to the interaction script.>	50 min	Rubric
8.	The teacher will summarize the sessions. • stress importance of classroom cleanliness. • reinforce data driven approach to address real-world issues. • remind students that school will seriously consider their proposals and adopt the best ones.	10 min	

Appendix I: A simplified problem-solving process

What is the problem?

↓

What are the initial possible solutions?

↓

- What information and data do we need in order to make informed decisions on what the solutions are?
- How can we collect those information and data?
- Who can we collect these from?
- What is the sample size (if applicable)?

↓

Analyze the information and data (e.g., pie chart, bar chart, mean, mode, median, etc.)

↓

What are the proposed solutions?

Appendix J: Pre-survey

Student ID:

School issue: *"How can a class work together to create a clean and conducive classroom environment for teaching and learning?"*

1) What is the problem **YOU** have chosen (come up with at least one e.g., classroom not clean, lessons not interesting, etc.)? What are your initial ideas or solutions to solve this school problem?

2) Please list and provide details of strategies that **YOU** intend to use to obtain data that you can analyze to come up with the proposal to tackle the school issue. In each of the strategies, please include details of **what**, **how**, **who**, and **sample size**. To help you come up with a proposal to tackle the issue:

- **What** information/data do you need? (E.g., different ideas on what possible solutions could be, what others think are best solutions, past experience, advice, etc.)
- **How** do you intend to collect these from? (E.g., internet search, email survey, conduct online survey, conduct online poll, email Mr/Ms Tan, ask classmates verbally, etc.)
- **Who** do you intend to collect these from? (E.g., schoolmates, classmates, outside friends, relatives, Mr/Ms Tan, etc.)
- What is the **sample size** (if applicable)?

You can give your responses in bullet form. Below are some examples in bullet form. Notice that each example includes details of **what**, **how**, **who**, and **sample size**.

Examples in bullet form:

1. *Search the internet for different ideas about what possible solutions could be.*
2. *Create survey questions and administer survey to one secondary three class to obtain schoolmates' ideas.*
3. *Approach and ask Mr Tan for advice and past experience.*

3) How are **YOU** going to analyze your data to come up with your proposal?

Appendix K: Post-survey

Student ID:

School issue: *"How can a class work together to create a clean and conducive classroom environment for teaching and learning?"*

1) What is the problem **YOUR GROUP** has chosen (come up with at least one e.g., classroom not clean, lessons not interesting, etc.)?

2) Please list and provide details of strategies that **YOUR GROUP** intends to use to obtain data that your group can analyze to come up with the proposal to tackle the school issue. In each of the strategies, please include details of **what**, **how**, **who**, **when**, and **sample size**. To help you come up with a proposal to tackle the issue:

- **What** information/data does your group need? (E.g., different ideas on what possible solutions could be, what others think are best solutions, past experience, advice, etc.)
- **How** does your group intend to collect these from? (E.g., internet search, email survey, conduct online survey, conduct online poll, email Mr/Ms Tan, ask classmates verbally, etc.)
- **Who** does your group intend to collect these from? (E.g., schoolmates, classmates, outside friends, relatives, Mr/Ms Tan, etc.)
- What is the **sample size** (if applicable)? (e.g., 40 students from class 2E2)
- Indicate **who** (you or your partner) is going to do what and **by when** should the person complete that task.

You can give your responses in bullet format. Below are some examples in bullet format. Notice that each example includes details of **what**, **how**, **who**, **when**, and **sample size**.

Examples in bullet form:

1. *Search the internet for different ideas about what possible solutions could be by both by 22 Mar.*
2. *Create survey questions and administer survey to one secondary three class to obtain schoolmates' ideas by me by 20 Mar.*
3. *Approach and ask Mr Tan for advice and past experience by my partner by 21 Mar.*

3) How is **YOUR GROUP** going to analyze the data to come up with your group's proposal?

Appendix L: Group proposal survey form

Student ID:

School issue: *"How can a class work together to create a clean and conducive classroom environment for teaching and learning?"*

1) What is the problem **YOUR GROUP** has chosen (write down at least one e.g., classroom not clean, lessons not interesting, etc.)?

2) Please list and provide details of **YOUR GROUP's proposed solutions** to address the school issue. In each of the proposed solutions, please include details of **what**, **when**, **how often**, and **who**:

- **What** is the solution? (E.g., recognition for class with cleanest classroom, etc.)
- **When** should this be carried out? (E.g., during term 1 week 2, from 7 July to 11 July 2014, from term 2 week 1 to term 2 week3, etc.)
- **How often** should be this carried out? (E.g., once a week on every Monday, once a month on every last assembly of the month, once a year during term 1 week 2, etc.)
- **Who** can be in charge of carrying out your proposed solutions (if applicable)? (E.g., schoolmates, classmates, student council cca group, teachers, etc.)

You can give your responses in bullet format. Below are some examples in bullet format. Notice that each example includes details of **what**, **when**, **how often**, and **who**.

Examples in bullet form:

1. *Announcement of top 3 cleanest class once a month during the last assembly of that month, starting from the assembly on 27 Mar. Announcement will also be placed on the tv screens throughout the school. School teachers in charge of discipline can grade classes on cleanliness.*
2. *Held once a year, the whole week after exams in May can be set aside to commemorate cleanliness. Line up activities and games such as AAA and BBB during that week to inculcate the habit of cleanliness in school. Different CCA groups can lead in the organization of the activities.*

3) Please list and provide details of **ALL** the strategies that **YOU AND YOUR PARTNER** had used to obtain data to help your group come up with the proposal to tackle the school issue. In each of the strategies, please include details of **what**, **how**, **who**, and **sample size**. To help you come up with a proposal to tackle the issue:

- **What** information/data did your group collect? (E.g., different ideas on what possible solutions could be, what others think are best solutions, past experience, advice, etc.)
- **How** did your group to collect these from? (E.g., internet search, email survey, conduct online survey, conduct online poll, email Mr/Ms Tan, ask classmates verbally, etc.)
- **Who** did your group collect these from? (E.g., schoolmates, classmates, outside friends, relatives, Mr/Ms Tan, etc.)
- What is the **sample size** (if applicable)? (e.g., 40 students from Secondary 2E2)

You can give your responses in bullet form. Below are some examples in bullet form. Notice that each example includes details of **what**, **how**, **who**, and **sample size**.

Examples in bullet form:

1. *Search the internet for different ideas about what possible solutions could be.*
2. *Create survey questions and administer survey to one secondary three class to obtain schoolmates' ideas.*
3. *Approach and ask Mr Tan for advice and past experience.*

4) If you had conducted any interviews or surveys to collect data, please:

1) Indicate the interview/survey questions that you had used;
2) Explain how you had used your data to come up with your proposed solutions.

Appendix M: Delete and thesaurus list

Delete list

All words that are trivial (e.g., conjunctions, et cetera) are deleted. Here are some examples where the underlined words will be deleted.

- Students are appointed to empty the waste paper basket.
- The form teacher and class monitor should record names of students who did not perform their duties.

Thesaurus list

The following contains an initial list of words that are to be treated as identical when the raters code the students' responses to the pre- and post-surveys. Subject to agreement from both raters as they code the actual responses, this list will be iteratively improved upon to include more similar words or new groups of similar words.

Additionally, depending on the context in the responses, some words that might belong to one group in the list might actually have the meaning of words in another group. For example, while a response could explicitly contain the word "friends", details from the response might indicate that "friends" refer to classmates. The rater will make his own judgment to infer the actual meaning of each word and place it in the appropriate group of similar words accordingly.

List of similar words	**Can be replaced by**
Students, student, pupil, pupils	Students
Classmates, classmate	Classmates
Schoolmates, schoolmate	schoolmates
School, education institution, XXX secondary, XXX sec, XXXSS (where SS denotes Secondary School)	XXXSS
Whiteboard, blackboard	Whiteboard
Dustbin, waste paper basket	Dustbin
Questionnaire, survey	Questionnaire
Internet, www, worldwide web	Internet
Online chat, msn, skype, gmail chat	Online chat
Email, gmail, yahoo mail, Hotmail	Email

Appendix N: Rubric to grade group proposal

Grading Criteria	**Possible points for each criteria**			
	1	**2**	**3**	**4**
Originality	Gives one hackneyed and unoriginal idea/suggestion.	Gives at least two hackneyed and unoriginal ideas/suggestions.	Gives at least one new or modified idea/suggestion.	Gives several original ideas/suggestions.
Team plan	Shows a disorganized plan without any details of proposed solutions.	Shows a disorganized plan with little details of proposed solutions.	Shows a somewhat organized plan with some details of proposed solutions.	Shows a well-organized plan with a lot of details of proposed solutions.
Data collected	Did not collect any data using any methods.	Collected data using one method.	Collected data using two methods.	Collected data using at least three methods.
Data analysis	Shows no attempt of evaluating and analyzing data.	Shows some evidence of evaluating and analyzing data.	Shows strong evidence of evaluating and analyzing data.	Shows an in-depth evaluation and analysis of data.
Data collection instrument	No survey/interview questions were asked or were relevant.	One survey/interview question was asked or was relevant.	At least two survey/interview questions were asked, and some were clear, relevant, and organized.	At least two survey/interview questions were asked, and all survey/interview questions were clear, relevant, and organized.

Appendix O: Updated Socio-cognitive Conflict Style Coding Scheme

Main Functional Moves	Specific Functional Moves	Description/Indicators	Examples
Avoiding/dominating/compromising/accommodating conflicts			
Avoiding	Postponing	• Putting off differences in ideas without discussion or giving reasons.	• "Let's skip this first, and move on to the next question."
	Passing the buck	• Asking someone (e.g., leader) to make decision on solution. • Simply saying one doesn't know.	• "Brian, we'll follow what you think is right." • "Don't know."; "No idea."
Forcing /competing /dominating	Asserting	• Insisting on using one's ideas. • Using one's or others' authority/expertise to get one's way or to make decisions. • Rejecting or disagreeing with others' opinions or making judgment without giving reasons.	• "I don't care what you all say, but I am 100% sure that my understanding is correct, and we should use my idea." • "I got the highest in our tests, and so I should be right."; "Let's use Sue's idea because she is smarter than any of us." • "I don't think your idea works. Let's use mine."; "I don't agree."
	Threatening	• Making threats to force others to comply.	• "One more word and I won't lend you my study notes."
	Justifying	• Providing reasons for one's ideas (e.g., with support from one's experience, textbook, etc.).	• "I am thinking that this should be the right solution because I remembered that there was a similar question with this solution in the textbook."

Main Functional Moves	Specific Functional Moves	Description/Indicators	Examples
Compromising	Voting	• Making decision based on majority of support for a particular idea.	• "How many think this idea is correct?"
	Using social negotiating	• Making decisions based on a purely social basis.	• "We used your ideas last time, so use mine this time."
	Proposing middle ground	• Taking bits of each idea without synthesizing or examining various perspectives.	• "So Roy thinks that the speed of the object increases the longer it falls, but Jay feels that the speed remains constant. Perhaps the speed increases only till a certain point, and then remains constant?"
	Trading off	• Giving up something in return for something else.	• "I'll be willing to use your method if you are willing to let me xxx."
Accommodating	Emphasizing commonalities	• Stressing areas that most/all agree.	• "At least I think all of us agree that one of the factors that affect resistance is the shape of the object."
	Acquiescing	• Giving in to others' opinions without evidence of any collaborative moves (see below).	• "Okay."

Main Functional Moves	Specific Functional Moves	Description/Indicators	Examples
		Embracing conflicts	
Collaborating	Sharing	• Putting forward one's views to start a discussion or when elicited by others.	• "I feel that XXX."
	Eliciting	• Asking others for opinions. • Seeking help to work out solution.	• "Peter, what do you think of his idea?" • "Sam, do you have any suggestions on how to solve this question?"
	Elaborating	• Providing more details or explanation.	• "I think the force that Mary was referring to is friction. Friction is a force that acts in the opposite direction of motion, and so slows down motion."
	Clarifying	• Verifying other's ideas. • Rephrasing or restating others' or one's views. • Asking others to elaborate.	• "Am I correct to say that you think that xxx?" • "When you say xxx, do you mean yyy?" • "When you say xxx, what do you mean?"
	Extending	• Building directly on others' ideas. • Making Inferences.	• "That would also mean that we have to xxx." • "That would imply that xxx."
	Exploring	• Analyzing implications or consequences. • Comparing ideas. • Testing ideas.	• "Bob's point is xxx. What would happen if we use his idea?" • "If we use John's idea, we would xxx. If we use Joe's idea, we would yyy." • "Let me try out this idea and see how it turns out before we make a decision."
	Qualifying	• Pointing out complexities in one's or others' ideas (e.g., restricting range of application of an idea). • Disagreeing with others' ideas with reasons given.	• "Yes, but this idea might not work if xxx." • "I don't agree because xxx."
	Synthesizing	• Linking ideas/interpretations.	• "Your idea and John's earlier point together would mean xxx."

The five main categories of functional moves:

1. Avoiding is associated with sidestepping, or passing-the-buck. When one avoids cognitive conflict, one does not face up to or confront the cognitive dissonance that is generated through one's interaction with others.

2. Forcing/competing/dominating is associated with forcing behaviors to win one's position, where one's own concerns are set above those of other parties in order to attain and/or maintain a higher position (e.g., being seen as right, or being knowledgeable).

3. Compromising is associated with finding a suitable mutually acceptable solution that partially satisfies all parties. It is associated with give-and-take where both parties give up something to come to a mutually acceptable decision.

4. Accommodating is associated with playing down the differences, and emphasizing commonalities. Such a move could involve some self-sacrifice, and is made usually to maintain good relationships.

5. Collaborating is the only one in which the learner embraces the cognitive conflict. There are evidences from the online interactions that the learner confronts and faces up to the cognitive dissonance one is experiencing through one's interaction with others. When collaborating, one tries to work together with other people to find a solution that satisfies the needs of everyone concerned. This style is associated with sharing of ideas, and examination of differences to reach a view acceptable to various parties.

8 VITA

San Chye Cheng

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