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The role of collective efficacy, cognitive quality, and task cohesion in computer-supported collaborative learning (CSCL)

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ABSTRACT

Research has suggested that CSCL environments contain fewer social context clues, resulting in various group processes, performance or motivation. This study thus attempts to explore the relationship among collective efficacy, group processes (i.e. task cohesion, cognitive quality) and collaborative performance in a CSCL environment. A total of 75 Taiwanese college students (divided into 25 groups) participated in the study. Both quantitative and qualitative methods were applied for data analysis. The results indicate that collective efficacy significantly predicted task cohesion but not cognitive quality in the CSCL environment. For the role of group processes in performance, both task cohesion and cognitive quality significantly predicted group performance, but cognitive quality predicted better than task cohesion. In addition, for the predictive capability of prior performance, task cohesion, and cognitive quality in collective efficacy, the results showed that only task cohesion predicted subsequent collective efficacy significantly in the CSCL environment.

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1. Introduction

Recent researchers have suggested that computer-supported collaborative learning (CSCL) plays an important role in learners' performance (Francescato et al., 2006; Wang & Lin, 2007b). For example, it has been suggested that CSCL helps students to facilitate high order cognitive processes and to create new knowledge (Bruckman & De Bonte, 1997; Butler, 1995; Francescato et al., 2006). However, other researchers have shown that students in CSCL environments contribute differently in cognitive activities (De Laat & Lally, 2003; Hurme, Palonen, & Järvelä, 2006) and in on-line discourse (Caspi, Chajut, Saporta, & Beyth-Marom, 2006; De Laat & Lally, 2003; Häkkinen & Järvelä, 2006; Salovaara & Järvelä, 2003). Research further suggests that motivation should play an important role in such varied contributions in CSCL discourse (Rienties, Tempelaar, Van den Bossche, Gijselaers, & Segers, 2009). As Bandura (1997, 2000) suggested, collective efficacy, the perception of group capability to achieve the goal, one of the most powerful group motivation beliefs, has positive influences on various areas of group learning and performance. However, very little research has examined the influences of collective efficacy in CSCL, this study thus attempts to investigate the role of collective efficacy on group process behaviors such as cognitive quality and task cohesion in the CSCL environment.

In addition, research has suggested that CSCL environments contain fewer social context cues (González, Burke, Santuzzi, & Bradley, 2003), as compared to traditional collaborative learning. For example, computer-supported collaborative learning in general is more text-based, and lacks physical gestures, tone of voice, and emotional expression, while traditional collaborative learning conveys more non-verbal information, such as status difference, appearance, and facial expression (González et al., 2003). Considering the absence of such social context clues, but with its text-based features, CSCL may result in various different group processes and performance. Although researchers have suggested that group process behaviors such as task cohesion and cognitive quality are important for group performance (Hooper, 2003; Willoughby, Wood, McDermott, & McLaren, 2000), whether these two constructs still exert the same significance in CSCL, which lacks social clues and teachers' monitoring, is in need of investigation. This study thus attempts to further investigate task cohesion and cognitive quality, as well as their importance in CSCL performance.

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Moreover, as previously noted, collective efficacy has strong effects on various aspects of collaborative learning. The factors influencing collective efficacy should be worthy of more attention. As Bandura (2000) suggested, group interaction processes play an important role in constructing collective efficacy, while researchers also suggest that the performance accomplishment of groups is the most powerful source of information for collective efficacy (Whyte, 1998; Zaccaro, Blair, Peterson, & Zazanis, 1995). Therefore, this research also attempts to investigate whether group process behaviors (i.e. group cohesion, cognitive quality) or prior group performance exerts stronger influences in developing collective efficacy in the CSCL environment. To further explore the role of task cohesion, cognitive quality and prior group performance in collective efficacy, collective efficacy is therefore administered twice in this study. This is also consistent with Klassen and Krawchuk's (2009) suggestion that collective efficacy is a socially shared cognition that develops over time.

2. Theoretical background

2.1. Collective efficacy, group process behaviors (task cohesion, cognitive quality), and group performance

According to Bandura (1997), collective efficacy is defined as a group's shared beliefs in its conjoined capabilities to execute the courses of action required to achieve assigned goals. In other words, collective efficacy is perceived as the performance capability of a group as a whole. Bandura (1997) also suggests that two descriptions of collective efficacy can be used to estimate perceived group efficacy. The personal description sums members' judgments of their own efficacy beliefs, while the group description aggregates the members' perceived efficacy of their group as a whole. Aggregated perceived group efficacy is particularly relevant when group goal attainment requires a significant interdependent effort. In this study, the collaborative tasks require highly interdependent effort, and all students need to contribute their efforts to achieve their group's goals.

Researchers have indicated that collective efficacy has strong influences on collaborative performance in schools, organizations and sport (Bandura, 1997; Goddard, 2001; Hodges & Carron, 1992; Peterson, Mitchell, Thompson, & Burr, 2000). A meta-analysis in collaborative learning indicates a significant positive relationship between collective efficacy and group performance (Gully, Beaubien, Incalcaterra, & Joshi, 2002). In addition to the significant impact on group performance, researchers have also suggested that collective efficacy has a significant effect on group processes, such as levels of effort, group cohesion and persistence (Bandura, 1997; 2000; Lee & Farh, 2004; Wang & Lin, 2007a). For example, a recent study has indicated that collective efficacy plays an important role in group cohesion (Lee & Farh, 2004). Mullen and Copper (1994) also suggest that task cohesion, focusing on task commitment, has a stronger relationship with collective efficacy than does social cohesion. Therefore, this study further hypothesizes that collective efficacy should have similar effects on task cohesion in the CSCL environment.

Moreover, researchers have extensively indicated that motivation is very critical for students' use of cognitive strategies or cognitive quality (Pintrich, 1999; Pintrich & De Groot, 1990; Pintrich & Schrauben, 1992; Schunk, Pintrich, & Meece, 2008; Wang & Lin, 2007a). Researchers also suggest that cognitive strategies on their own cannot promote learning; students need to be motivated to do so (Pintrich & De Groot, 1990). A recent study in CSCL indicates that highly intrinsic motivated learners contribute both more and a higher quality of cognitive discourse in CSCL (Rienties et al., 2009), but there is still very limited attention on the influence of collective efficacy on cognitive quality in CSCL. This study thus attempts to further empirically examine the role of collective efficacy in cognitive quality in the CSCL environment.

2.2. Group cohesion, cognitive quality and group performance

Group cohesion has been found to exert an important impact on group dynamics or group processes in various areas, such as organizations, schools and sports (Mullen & Copper, 1994). According to González et al. (2003), group cohesion is the force to bind group members together to commit to the group goals. Two aspects of group cohesion are in general noted: one is social cohesion, addressing interpersonal attractions, and the other is task cohesion, focusing on task commitment. As the research suggests, social cohesion, which represents the degree of positive relationships among group members, leads to more frequent interactions (Zaccaro & Lowe, 1988). On the other hand, task cohesion, which shows group members' commitment to the group task, enhances group productivity.

Research in general has shown that group cohesion is positively related to group performance (Mullen & Copper, 1994). In a meta-analysis of 49 studies evaluating the effects of group cohesion on group performance, the results indicate that the cohesion-performance effect is highly significant but of small magnitude (Mullen & Copper, 1994). Although researchers in general support that both social and task cohesion are important group processes (Zaccaro, 1991; Zaccaro & Lowe, 1988; Zaccaro & McCoy, 1988), the meta-analysis reveals that only task cohesion positively predicts group performance (Mullen & Copper, 1994). González et al. (2003) also further validate the positive influence of task cohesion on the quality of group work. This study thus attempts to use task cohesion to predict CSCL performance in this study.

In addition to task cohesion, the cognitive quality of members' discourse should also be important for CSCL performance. Researchers have shown that students using higher level learning strategies have better performance (Garavalia & Gredler, 2002; Pintrich & De Groot, 1990; Schunk et al., 2008). Willoughby et al. (2000) further suggest that, when sophisticated strategic information can be shared within the group, the group members are more likely to make contributions which promote knowledge. However, research has rarely investigated the cognitive quality of on-line collaborative discourse in the CSCL environment. This study thus attempts to investigate the cognitive quality of on-line discourse along with its influences on computer-supported collaborative performance.

2.3. The role of prior group performance and group process behaviors (task cohesion, cognitive quality) in collective efficacy

Given the strong influences of collective efficacy on group processes and collaborative performance as previously noted (Bandura, 1997; Goddard, 2001; Peterson et al., 2000; Zaccaro et al., 1995), it is important to explore the factors affecting collective efficacy, which should help to facilitate collaborative learning. Researchers have suggested that, collective efficacy, a similar construct to self-efficacy, is derived from four major sources: prior performance, vicarious performance, verbal persuasion, and emotional arousal (Bandura, 1997; Whyte, 1998). Among these sources, prior group performance accomplishment plays the most important role in forming collective efficacy (Zaccaro et al., 1995). Successes raise efficacy beliefs, while failures decrease efficacy beliefs (Goddard, LoGerfo, & Hoy, 2004; Lee & Farh, 2004). In a study of 260 undergraduate students in a collaborative task, the results indicate that past performance rather than future performance is significantly related to collective efficacy (Lee & Farh, 2004). A study by Goddard et al. (2004) consistently indicates that collective efficacy is positively influenced by past mastery performance.

On the other hand, researchers indicate that group process behaviors may also play an important role in constructing collective efficacy (Yager, Johnson, Johnson, & Snider, 1986; Zaccaro et al., 1995). For example, research shows that group cohesion was significantly related to students' collective efficacy, both prior to and after completing their group assignment (Sue-Chan & Sargent, 1999). In a study investigating 165 undergraduates solving an engineering collaborative task, the results also indicated that collective efficacy can be strongly predicted by task cohesion (Lent, Schmidt, & Schmidt, 2006). In addition, for the relationship between cognitive quality and collective efficacy, many researchers have perceived motivation (e.g. collective efficacy) as a stimulator for the uses of cognitive strategies or quality (Pintrich & De Groot, 1990; Pintrich & Schrauben, 1992; Schunk et al., 2008; Wang & Lin, 2007a). However, in collaborative learning, the initial efficacy beliefs may also stimulate students' use of cognitive quality, but the cognitive quality of sharing ideas through interactions may in turn reinforce students' subsequent collective efficacy beliefs. Indeed, as Bandura (1997) suggested, collective efficacy is very likely conveyed by group interaction processes. Therefore, this study hypothesizes that students' cognitive quality or task cohesion during group interaction is important in constructing collective efficacy in the CSCL environment, although recent research shows that students in CSCL tend to work less on processing knowledge and lack consensus (e.g. cohesion) when compared to traditional environment (Chiu, 2003; Chiu & Hsiao, 2010). To date, it is still unknown whether prior group performance or group process behaviors (i.e. task cohesion and cognitive quality of discourse) play a more important role in collective efficacy in the CSCL environment. This study thus attempts to investigate the predictive capability of prior group performance, task cohesion, and cognitive quality in collective efficacy in the CSCL environment.

3. Research questions (shown in Fig. 1)

1. What is the role of students' collective efficacy in their group process behaviors (task cohesion, cognitive quality) in the CSCL environment?
2. Do students' group process behaviors (task cohesion, cognitive quality) predict their computer-supported collaborative learning performance?
3. What is the predictive capability of prior group performance and group process behaviors (task cohesion and cognitive quality) for subsequent collective efficacy in CSCL?

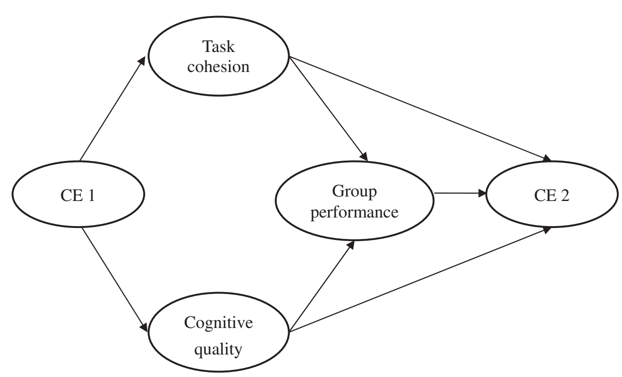

Fig. 1. The model for the relationship among collective efficacy (CE 1), task cohesion, cognitive quality, group performance, and subsequent collective efficacy (CE 2).

4. Methodology

4.1. Participants

75 Taiwanese college students from two classes of a "Web Page Programming" course at a central university participated in two collaborative tasks administered in this study. These students were majoring in Computer Science. Because they were requested to collaborate with others to complete their group projects, all students needed to choose their own group members in the class. Each group consisted of three students, and every student could freely choose their group members. All students had previously enrolled in "HTML Programming", so they had prior knowledge of ASP.NET, one of the popular computer languages for developing web-based systems (LeBlond & Kittel, 2004; Tseng, Hwang, Tsai, & Tsai, 2009). Moreover, the two classes were taught by the same teacher; therefore, their learning content and scheduled progress were identical.

4.2. Instruments

4.2.1. The networked system

The "Intelligent Collaborative Learning System" developed by Intelligent Distance Learning System Laboratory, which has been proved to have good applicability and functionality (Chu & Hwang, 2010). The collaborative learning system was developed to assist the teachers in

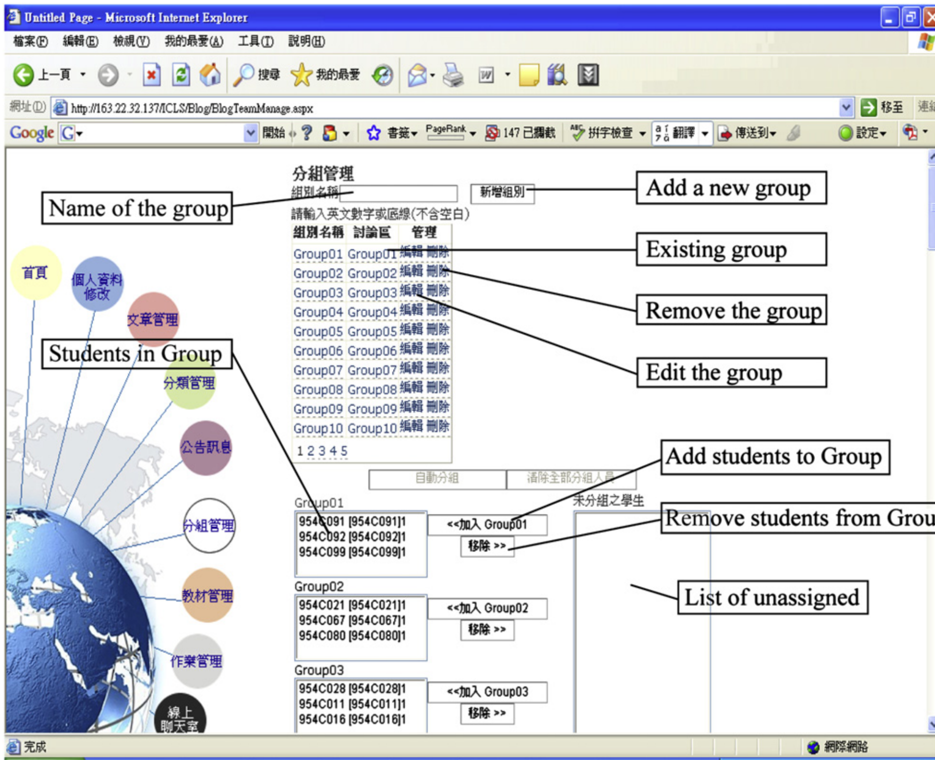

Fig. 2. Interface of the cooperative learning group management function.

conducting cooperative learning activities and managing the learning portfolio of cooperative learning groups. Fig. 2 shows the interface of the cooperative learning group management function, which allows teachers to compose cooperative learning groups in a manual or an automatic manner. In addition, a discussion area management function is provided, which enables teachers to browse the contents of the discussion area for individual cooperative learning groups. The system also allowed the students to discuss and upload their group projects, as shown in Fig. 3. All the students' group discussions were analyzed using the content analysis methods for their levels of cognitive quality based on Bloom's (1956) cognitive levels.

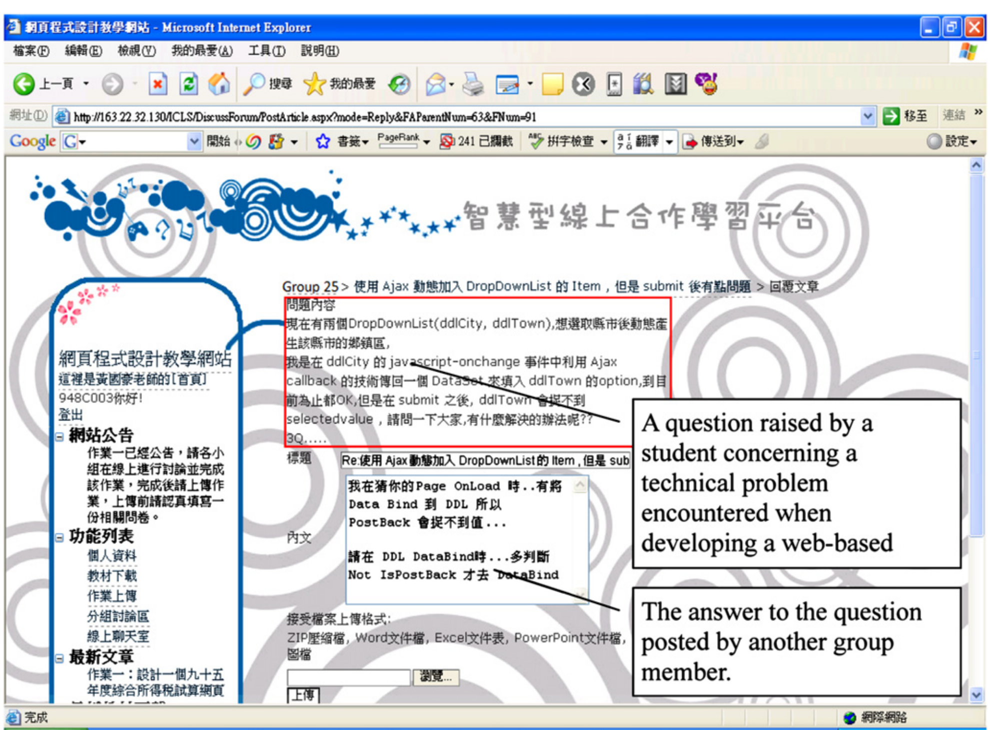

Fig. 3. The discussion board for group discussion.

4.2.2. Questionnaire

A questionnaire consisting of "collective efficacy" and "task cohesion" scales using a seven-point Likert scale ranging from (1) "not at all true of me" to (7) "very true of me" was administered in this study.

Collective Efficacy: As Bandura (1997) suggested, collective efficacy and self-efficacy are very similar constructs. The major difference between these two constructs is that self-efficacy is the perception of individual capability to attain the goal, while collective efficacy is the perception of group capability to achieve the goal. Researchers have developed the scale of "collective efficacy" based on the scale of self-efficacy (Wang & Lin, 2007b). Collective efficacy is concerned with the performance capability of a whole group, so eight items of self-efficacy were revised from the individual to the group level. For example, items of self-efficacy such as "I believe that I can understand the most difficult part of this course" were revised to "I believe that my group can understand the most difficult part of this course". The scale of collective efficacy has been proved to be valid and reliable in a recent CSCL study (Wang & Lin, 2007b).

Task cohesion: The scale of group cohesion was revised from Zaccaro (1991), Seibold and Kelly's (1988) questionnaires. The scale consisted of 6 items (for example, "Our team members were very involved in our teamwork").

The questionnaire consisted of a total of 14 items. For the reliability of the questionnaire, the reliability test showed that the scales of "collective efficacy" and "task cohesion" were very reliable, with an alpha of 0.916 for collective efficacy, and 0.944 for task cohesion. The factor analysis indicated that all items loaded on the expected factors, and these loadings were 0.672–0.799 for collective efficacy, and 0.664–0.880 for task cohesion. All these results showed that the instruments used in this study were reliable.

4.3. Collaborative task

One of the major objectives of this course was to enhance students' programming capability for developing web-based systems. To accomplish this objective, the collaborative learning tasks for each group of students were to develop a web-based income tax estimating system, which requires both financial knowledge and programming skills. The students were asked to develop a web-based system that provided at least two ways for guiding the users to estimate their income tax; that is, the "simplified procedure" (project 1) and the "standard procedure" (project 2) announced and demonstrated by a tax bureau. The web site of the Taipei tax bureau was given in the on-line discussion forum as a demo site for the learning task. The two collaborative projects were highly related, with the second project being more advanced than the first one.

In addition to the web-based programming skills learned in the class, the students required basic knowledge about income tax in order to complete the learning task. As the students were not knowledgeable about income tax, they needed to search for the relevant information before starting their learning task. The assessment of group projects consisted of correctness (30%), integrity (30%), usability (20%), and quality of layout (20%). To complete the group projects at a high level of quality, all group members needed to contribute their efforts to the group work, since the projects were designed as ill-structured tasks requiring more interdependent effort to achieve the group goal.

4.4. Procedure

The instructor announced the collaborative tasks in the first week. The students were requested to discuss their group projects using the "Intelligent Collaborative Learning System" over a period of six weeks. The students discussed their first collaborative project during the 2nd to 4th weeks, and the second project from the 6th to 8th weeks with their group members in either the synchronous or non-synchronous on-line chat room provided by the system. For the first project, all students had to fill out the questionnaire of "collective efficacy" and "task cohesion" through the system, which would then allow them to upload the project. Most data were collected from the collaborative process of the first project, except for the second questionnaire of "collective efficacy" (i.e. subsequent collective efficacy), which was collected from the second project. The collection of "collective efficacy" from the second project was aimed at investigating the predictive capability of prior project performance, and group process behaviors (i.e. task cohesion, cognitive quality) on collective efficacy, which has been suggested to develop over time. To encourage the students' participation in the on-line discussion, the instructor evaluated students' discussions based on their cognitive quality, which counted for 15% of their final grade.

4.5. Content analysis

The quality of the students' cognitive ideas in on-line discussion was also analyzed. The raters analyzed the discussion content based on the paragraphs about the discussion posted by students on the networked system. Each paragraph may present one or more ideas, and each idea was considered as one unit to be analyzed. If one paragraph comprised two ideas, two separate analytical units were counted. If two continuous paragraphs expressed the same idea, they were counted as a single analytical unit. The assessment of students' cognitive quality during the on-line discussion was based on Bloom's (1956) taxonomy of educational objectives. A recent web-based study using Bloom's taxonomy indicated that students' better cognitive quality in learning significantly was related to their academic achievement, which validated the use of Bloom's taxonomy in web-based learning (Hwang, Wang, Hwang, Huang, & Huang, 2008). The taxonomy consisted of six cognitive levels, ranking from knowledge (i.e. the recall of previous learned information), comprehension (i.e. the understanding of the meaning of a concept), application (i.e. the ability to use learned knowledge in a new situation or context), analysis (i.e. the ability to classify concepts into component parts and to make analysis), synthesis (i.e. the ability to integrate ideas into a product or new concept) to evaluation (i.e. the ability to judge the value of material or knowledge on a basis of specific standards) (Hwang et al., 2008). The ratings for students' on-line messages from the knowledge to evaluation levels were scored from 1 to 6 points, respectively. Our data showed that the students generated ideas only at the levels of knowledge, comprehension, and application, possibly due to the fact that our projects were designed for the students to apply their knowledge in developing an income tax estimating system, thereby inducing them to only present their cognitive level of knowledge, comprehension, and application. In addition, it is important to note that only cognitive-related (or task-related) interactions were evaluated for cognitive quality, while off-task discussions were not measured in this study.

This study assessed on-line discourse using content analysis, which can involve both numeric and interpretive data analysis, as suggested by researchers (Hara, Bonk, & Angeli, 2000). To achieve a more meaningful analysis of the on-line discussion, some quantitative analyses were also applied. The inter-rater consistencies were calculated by the Pearson product moment correlation. The correlation results indicate that the inter-rater reliability was good with 0.80. This demonstrates that content analysis is a reliable measure for discussion behaviors.

5. Results

The descriptive statistics shows an average score of 4.98 for collective efficacy ($M = 4.98$, $SD = 0.63$) and 5.89 for task cohesion ($M = 5.89$, $SD = 0.66$). In addition, for the content analysis of cognitive quality, Table 1 shows the examples and descriptive statistics (e.g. Mean, SD) of different cognitive levels based on the content analysis of students' on-line discussion. For example, as shown in Table 1, a posted message "The validation should use RequireFieldator as indicated in chapter 6", a recall of knowledge from the textbook, was considered as knowledge level. In addition, the message was coded as comprehension focusing on the understanding of the meaning of the concept, while the other message was classified as application focusing on students applying learned knowledge in a new situation or context (Bloom, 1956). It should be noted that, in learning the programming task in this study, "comprehension" refers to "the understanding of the programming language statements or operations", while "application" refers to "knowing when and how to apply the commands or operations to accomplish the learning tasks". So the example message of application, which focused on how to apply knowledge or perform some operation (i.e. search and replace some content) in the group projects instead of focusing on understanding the meaning of the programming language statements, was classified as the "application" level. The descriptive statistics of the content analysis indicated that the students' cognitive ideas in their on-line discussion were approximately 42% for knowledge, 41% for comprehension, and only 17% for application level. The results also showed no significant relation between two group process behaviors, such as task cohesion and cognitive levels.

The results for the research questions are as follows:

Table 1
Examples and descriptive statistics for cognitive quality in on-line group discussion ($N = 25$ groups).

Cognitive levels	Examples of cognitive quality in content analysis	*M*	SD	Total
Knowledge	"The validation should use Fieldvalidator as shown in chapter 6".	4.68	7.68	117
Comprehension	"You should use "Label" instead of "text" since "text" is used to receive inputted data from users, while the value of "label" cannot be modified by users".	4.44	8.97	111
Application	"I think you need to modify the content of the "aspx" file, which can be done by searching for the string "<link id="ss" href="css/ss01.css" rel="stylesheet&quot" and then replace the substring "href="ss1.css&quot" with "href="css/ss01.css&quot".	1.62	2.98	40.5

5.1. *What is the role of students' collective efficacy in their group process behaviors (group cohesion, cognitive quality) in the CSCL environment?*

For the role of collective efficacy in computer-supported collaborative behaviors, the results indicated that collective efficacy ($\beta = 0.796$, $t = 6.296$, $p < .001$) only predicted task cohesion significantly in CSCL. In other words, students with higher collective efficacy were more likely to make commitment together in their group projects. However, collective efficacy did not significantly predict the students' cognitive quality of all levels in the CSCL environment.

5.2. *Do students' group process behaviors (cognitive quality, task cohesion) predict their computer-supported collaborative learning performance?*

For the predictive capability of cognitive quality in CSCL performance, the results indicated that groups with more knowledge ($\beta = -0.210$, $t = -0.496$, $p > 0.05$) and understanding levels of cognitive ideas ($\beta = -0.101$, $t = -0.229$, $p > .05$) cannot predict CSCL performance significantly, but their application level of cognitive ideas ($\beta = 0.758$, $t = 3.340$, $p < .01$) significantly predicted CSCL performance. Because the application level of cognitive ideas is usually considered as better cognitive quality when compared to the knowledge and comprehensive levels, it thus presented the cognitive quality in our analysis. When task cohesion and cognitive quality were used to predict the CSCL performance, the results indicated that both task cohesion ($\beta = 0.351$, $t = 2.158$, $p < 0.05$) and cognitive quality ($\beta = 0.499$, $t = 3.063$, $p < 0.05$) can predict performance significantly. In other words, both task cohesion and ideas of better cognitive quality (i.e. application) in the students' discussion led to better group performance.

5.3. *What is the predictive capability of prior group performance and group process behaviors (task cohesion and cognitive quality) for subsequent collective efficacy in CSCL?*

For the predictive capability of group performance, task cohesion, and cognitive quality for subsequent collective efficacy, the results indicated that students' task cohesion ($\beta = 0.516$, $t = 2.631$, $p < 0.05$) significantly predicted subsequent collective efficacy, while prior group performance ($\beta = 0.202$, $t = 0.865$, $p > 0.05$) and cognitive quality ($\beta = -0.258$, $t = -1.214$, $p > 0.05$) did not (shown in Table 2). The results of the path model were shown in Fig. 4.

Table 2
The regression analysis of group performance, task cohesion and cognitive quality on collective efficacy.

Dependent variable	Predictive variables	R^2	β	t
Collective efficacy	Group performance	0.357	0.202	0.865
	Task cohesion		0.516*	2.631
	Cognitive quality		−0.258	−1.214

*$p < .05$.

6. Discussion and conclusion

In summary, the results indicate that collective efficacy significantly predicts task cohesion but not cognitive quality in the CSCL environment. For the role of group process behaviors in performance, both task cohesion and cognitive quality significantly predict group performance, but cognitive quality predicts group performance better than task cohesion. In addition, for the role of prior group performance, task cohesion and cognitive quality in collective efficacy, the results show that only task cohesion predicts subsequent collective efficacy significantly in the CSCL environment.

Previous studies in general support that motivation has a positive impact on students' cognitive quality or use of cognitive strategies in learning (Cho & Johassen, 2009; Pintrich & De Groot, 1990; Schunk et al., 2008). For example, Rienties et al. (2009) indicate that individuals with higher intrinsic motivation contribute better cognitive quality of on-line discourse in CSCL. However, our result shows that collective efficacy does not predict students' cognitive activities, which is different from Reinties and their colleagues' (2009) findings, possibly due to the fact that their study is based on the individual level of motivation, while ours is focused on collective efficacy of the group as a whole. However, more investigation on the role of motivational beliefs on the cognitive quality of on-line discourse in CSCL is needed in future research. In addition, our results show that collective efficacy is more predictive of students' task cohesion than cognitive quality for their collaborative work in CSCL. It seems that students' collective efficacy to achieve the goals are more related to their perceptions of their commitment to the group work rather than to their cognitive quality in on-line discussion in the CSCL environment. When students believe that their groups can succeed in their collaborative task, they are more likely to commit more to their task, although they do not produce better cognitive quality. Our data do show no relationship between task cohesion and cognitive quality; that is, groups with better task cohesion do not have higher cognitive quality of on-line discussion when solving the collaborative tasks.

For the role of group process behaviors in collaborative performance, both task cohesion and cognitive quality significantly predict CSCL performance. Our results indicate that cognitive quality of on-line discussion predicts CSCL performance better than task cohesion. Although the results indicate that groups with higher task cohesion have better performance, it also shows that groups which can utilize the application in solving the collaborative tasks exert a stronger influence on collaborative performance. The result is consistent with previous findings that cognitive strategy is usually more directly related to students' academic performance (Pintrich & De Groot, 1990; Pintrich & Schrauben, 1992; Schunk et al., 2008). Elliot, McGregor, and Gable (1999) also suggest a possible connection between deep (e.g. high level) processing strategies and long-term learning effects. This study further validates that cognitive quality of on-line discussion is also influential in group performance in the CSCL environment. A recent study in CSCL has suggested that providing students with an interdisciplinary context may help them magnify their cognitive analysis (Pereira, Zebende, & Moret, 2010). Thus, teachers may implement a learning task in an interdisciplinary environment to promote students' cognitive involvement in on-line discussion.

Although our results show that cognitive quality significantly predicts performance, a limitation of our study is that students' cognitive level is only represented up to application level. This is possibly due to the fact that our collaborative tasks were designed for the students to apply their knowledge in developing a web-based system, which may limit them to expressing their cognitive ideas to no higher than the application level, although we did attempt to make the task ill-structured and requiring more interdependent effort, such as searching for and integrating information. Future research may consider providing students with tasks that not only apply knowledge in learning situations but also require the students to synthesize or evaluate knowledge in learning, which may help to better understand the role of cognitive quality in CSCL. It is suggested that providing a challenging CSCL task that requires students to perform higher level cognitive processes to succeed should promote students' better cognitive quality in learning.

For the role of prior group performance and group process behaviors (i.e. task cohesion, cognitive quality) in the construction of collective efficacy in the CSCL environment, the results indicate that only task cohesion significantly predicts collective efficacy. Although research

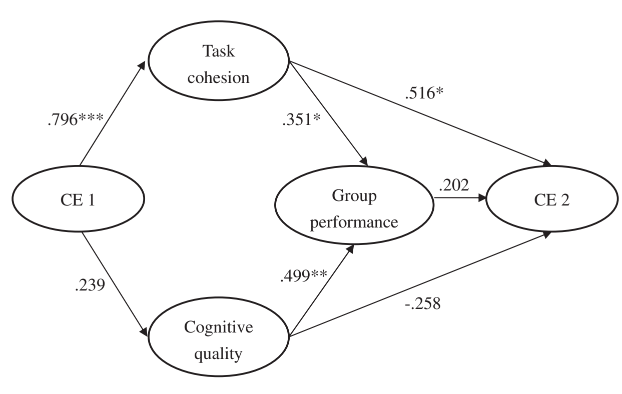

Fig. 4. The analysis for collective efficacy (CE 1), task cohesion, cognitive quality, group performance, and subsequent collective efficacy (CE 2).

suggests that prior group performance provides the most reliable information for constructing collective efficacy (Whyte, 1998), our results only show that group process behaviors such as task cohesion promote students' collective efficacy to achieve their group goals in the CSCL environment. It is possible that students' general perceptions of commitment to the group work in constructing collective efficacy are particularly influential in the CSCL environment, which lack social context clues such as voice tones, body gestures and emotional expression. When students perceive their group members making a commitment during the distant collaborative process, they are more likely to believe that their groups should achieve the goal. In addition, although the other group process behavior, cognitive quality, predicts CSCL performance better than task cohesion, it does not significantly predict collective efficacy. It seems that cognitive quality ideas are important for performance, but they may not be sufficient to promote their collective efficacy in the CSCL environment in our study, possibly due to the fact that the quantity of high cognitive quality ideas that each group generated was limited, making it difficult to convey the information about the group's capability to achieve the goal. In other words, the quantity of cognitive ideas through interaction may play an important role in conveying information of collective efficacy. On the other hand, task cohesion, based on the general perception of group commitment during the collaborative process, is more helpful in constructing the beliefs in group capability to attain the goal. To some extent, our findings partially support Bandura's notion that collective efficacy is very likely influenced by group interaction processes (Bandura, 1997), in the CSCL environment.

For the role of task cohesion in CSCL, the results indicate that task cohesion is a significant mediator among collective efficacy, CSCL performance, and subsequent collective efficacy. This finding is consistent with a previous study conducted by González et al. (2003) using SEM (structural equation modeling), which indicates that task cohesion serves as a better mediator than collective efficacy among collective efficacy, task cohesion, and performance. Our results further validate that task cohesion may in turn influence students' subsequent collective efficacy. Therefore, it is important to promote task cohesion in order to enhance collaborative motivation and performance in the CSCL environment. To promote task cohesion, positive interdependence is required. Research suggests that when tasks require high interdependence, task cohesion should help to enhance the communication process within the group, which in turn influences group performance (González et al., 2003). Thus, the teacher may provide tasks that are ill-structured and require more interdependent effort. So students are more likely to communicate with each other and commit to the group work in order to attain their group goals. In addition, task difficulty may also influence students' task cohesion (Abrami et al., 1996). When the task is too easy, it is possible that only one capable member may complete the collaborative task, which reduces the group members' commitment to the task and may also result in the free riders effect (Abrami et al., 1996). Moreover, group size is another factor which needs to be considered. As the research suggests, a small group size helps to produce higher task cohesion, because it is easy for group members to communicate to achieve consensus (Widmeyer, Brawley, & Carron, 1990). On the other hand, groups with more members may have fewer interactions and so it is harder to achieve a consensus, resulting in low task cohesion and also leading to the social loafing effect.

Consistent with Tai's (2008) suggestion that motivation is a prerequisite in on-line learning, our results indicate that collective efficacy significantly motivates group members' commitment to the collaborative work (task cohesion), which in turn influences collaborative performance. Therefore, it is helpful to further explore the factors influencing collective efficacy in order to promote collaborative learning. As the research suggests, collective efficacy is very similar to the self-efficacy construct, in that the factors influencing self-efficacy may possibly have similar effects on collective efficacy (Bandura, 1997). For example, research has suggested that properties of goal setting, such as proximity, difficulty, and specificity, have all been proved to have significant impacts on self-efficacy (Schunk et al., 2008; Wang & Lin, 2007a); future research may empirically investigate the impacts of these properties in collective efficacy in CSCL. In addition, feedback behaviors have also been shown to have significant effects on self-efficacy (Wang & Wu, 2008), so it is also reasonable to assume that groups with better feedback should have higher collective efficacy in collaborative tasks. Moreover, although research proposes that observing similar others performing well on the task (i.e. modeling) may also convey a strong sense of efficacy beliefs (Wang & Lin, 2007a), the influences of modeling effects on collective efficacy through group interaction also need to be empirically examined in future studies. Besides, in our study, the measurement of collective efficacy and task cohesion is only based on the students' self-report questionnaire, which may not be able to acquire in-depth information; this is considered as a limitation of our study. Thus, future research may apply triangulation techniques (e.g. interviews) to explore more in-depth information for students' collective efficacy, and task cohesion, which may help lead to a better understanding of the relationship among collective efficacy, task cohesion, and cognitive quality in CSCL.

The social cognitive perspective of self-regulated learning, which emphasizes the interactions among personal, behavioral, and environmental factors, has suggested that high self-regulated learners possess higher motivational beliefs (personal), apply better learning behaviors (behavioral), and receive better performance evaluations or peer feedback (environmental), which in turn affects their motivational beliefs (Bandura, 1997; Järvelä, Järvenoja, & Veermans, 2008; Schunk et al., 2008; Wang & Lin, 2007a; Wang & Wu, 2008). Recent research also has suggested that current social cognitive models are mostly focused on the individual basis of analysis (Järvelä et al., 2008). This study further supports the social cognitive model of regulated learning on a group basis, in which groups with higher collective efficacy (personal) have greater task cohesion (behavioral), and thus obtain better performance evaluation (environmental) as well as higher collective efficacy (personal), which validates the possible interactions among personal, behavioral and environmental factors in CSCL. Accordingly, recent researchers have suggested that regulated learning on a group basis could lead to co-regulation or socially shared regulation, which often occurs in the technology-based learning environment and focuses on collective interactions as well as collaboration (Hadwin, Oshige, Gress, & Winne, 2010). In order to promote collaborative learning in the technology-based environment, future research should explore more personal, behavioral and environmental factors in co-regulation or socially shared regulated learning in the CSCL environment.

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References

Abrami, P. C., Chambers, B., Poulsen, C., De Simone, C., d' Apollonia, S., & Howden, J. (1996). *Classroom connections: Understanding and using cooperative learning*. New York: Harcourt Brace.

Bandura, A. (1997). *Self-efficacy: The exercise of control*. NY: Freeman.

Bandura, A. (2000). Exercise of human agency through collective efficacy. *Current Directions in Psychological Science, 9*, 75–78.

Bloom, B. S. (1956). *Taxonomy of educational objectives: Handbook of cognitive domain*. New York: McKay.

Bruckman, A., & De Bonte, A. (1997). MOOSE goes to school: a comparison of three classrooms using a CSCL environment. In R. Hall, N. Miyake, & N. Enyedy (Eds.), *Computer support for collaborative learning, proceedings of the second international conference on computer support for collaborative learning* (pp. 20–26), Toronto, Canada.

Butler, W. M. (1995). Writing to learn history on-line. *Learning House, 69*, 17–27.

Caspi, A., Chajut, E., Saporta, K., & Beyth-Marom, R. (2006). The influence of personality on social participation in learning environments. *Learning and Individual Differences, 16*(2), 129–144.

Chiu, C. H. (2003). Exploring how primary school students function in computer supported collaborative learning. *International Journal of Continuing Engineering Education and Life Long Learning, 13*(3), 258–267.

Chiu, C. H., & Hsiao, H. F. (2010). Group differences in computer supported collaborative learning: evidence from patterns of Taiwanese students' online communication. *Computers & Education, 54*, 427–435.

Cho, M., & Johassen, D. (2009). Development of the human interaction dimension of the self-regulated learning questionnaire in asynchronous online learning environments. *Educational Psychology, 29*(1), 117–138.

Chu, H. C., & Hwang, G. J. (2010). Development of a project-based cooperative learning environment for computer programming courses. *International Journal of Innovation and Learning, 8*(3), 256–266.

De Laat, M., & Lally, V. (2003). Complexity, theory and praxis: researching collaborative learning and tutoring processes in a networked learning community. *Instructional Science, 31*(1–2), 7–39.

Elliot, A. J., McGregor, H. A., & Gable, S. (1999). Achievement goals, study strategies, and exam performance: a mediational analysis. *Journal of Educational Psychology, 91*, 549–563.

Francescato, D., Porcelli, R., Mebane, M., Cuddetta, M., Klobas, J., & Renzi, P. (2006). Evaluation of the efficacy of collaborative learning in face-to-face and computer-supported university contexts. *Computers in Human Behavior, 22*(2), 163–176.

Garavalia, L. S., & Gredler, M. E. (2002). Prior achievement, aptitude, and use of learning strategies as predictors of college student achievement. *College Student Journal, 36*(4), 616–626.

Goddard, R. D. (2001). Collective efficacy: a neglected construct in the study of schools and student achievement. *Journal of Educational Psychology, 93*, 467–476.

Goddard, R. D., LoGerfo, L., & Hoy, W. K. (2004). High school accountability: the role of perceived collective efficacy. *Educational Policy, 18*(3), 403–424.

González, M. G., Burke, M. J., Santuzzi, A. M., & Bradley, J. C. (2003). The impact of group process variables on the effectiveness of distance collaboration groups. *Computers in Human Behavior, 19*(5), 629–648.

Gully, S. M., Beaubien, J. M., Incalcaterra, K. A., & Joshi, A. (2002). A meta-analytic investigation of the relationship between team efficacy, potency, and performance. *Journal of Applied Psychology, 87*(5), 819.

Hadwin, A. F., Oshige, M., Gress, C. L. Z., & Winne, P. H. (2010). Innovative ways for using gStudy to orchestrate and research social aspects of self-regulated learning. *Computers in Human Behavior, 26*(5), 794–805.

Häkkinen, P., & Järvelä, S. (2006). Sharing and constructing perspectives in web-based conferencing. *Computers & Education, 47*(4), 433–447.

Hara, N., Bonk, C. J., & Angeli, C. (2000). Content analysis of online discussion in an applied educational psychology course. *Instructional Science, 28*(2), 115–152.

Hodges, L., & Carron, A. V. (1992). Collective efficacy and group performance. *International Journal of Sport Psychology, 23*(1), 48–59.

Hooper, S. (2003). The effects of persistence and small group interaction during computer-based instruction. *Computers in Human Behavior, 19*(2), 211–220.

Hurme, T. R., Palonen, T., & Järvelä, S. (2006). Metacognition in joint discussions: an analysis of the patterns of interaction and the metacognitive content of the networked discussions in mathematics. *Metacognition and Learning, 1*(2), 181–200.

Hwang, W. Y., Wang, C. Y., Hwang, G. J., Huang, Y. M., & Huang, S. (2008). A web-based programming learning environment to support cognitive development. *Interacting with Computers, 20*, 524–534.

Järvelä, S., Järvenoja, H., & Veermans, M. (2008). Understanding the dynamics of motivation in socially shared learning. *International Journal of Educational Research, 47*, 122–135.

Klassen, R. M., & Krawchuk, L. L. (2009). Collective motivation beliefs of early adolescents working in small groups. *Journal of School Psychology, 47*(2), 101–120.

LeBlond, G. T., & Kittel, M. A. (2004). *ASP.NET cookbook*. O'Reilly.

Lee, C., & Farh, J. L. (2004). Joint effects of group efficacy and gender diversity on group cohesion and performance. *Applied Psychology: An International Review, 53*(1), 136–154.

Lent, R. W., Schmidt, J., & Schmidt, L. (2006). Collective efficacy beliefs in student work teams: relation to self-efficacy, cohesion, and performance. *Journal of Vocational Behavior, 68*(1), 73–84.

Mullen, B., & Copper, C. (1994). The relationship between group cohesiveness and performance: an integration. *Psychological Bulletin, 115*(2), 210–227.

Pereira, H. B. B., Zebende, G. F., & Moret, M. A. (2010). Learning computer programming: implementing a fractal in a Turing Machine. *Computers & Education, 55*, 767–776.

Peterson, E., Mitchell, T. R., Thompson, L., & Burr, R. (2000). Collective efficacy and aspects of shared mental models as predictors of performance over time in work groups. *Group Processes & Intergroup Relations, 3*(3), 296.

Pintrich, P. R. (1999). The role of motivation in promoting and sustaining self-regulated learning. *International Journal of Educational Research, 31*(6), 459–470.

Pintrich, P. R., & De Groot, E. V. (1990). Motivational and self-regulated learning components of classroom academic performance. *Journal of Educational Psychology, 82*(1), 33–40.

Pintrich, P. R., & Schrauben, B. (1992). Students' motivational beliefs and their cognitive engagement in classroom academic tasks. *Student Perceptions in The Classroom*, 149–183.

Rienties, B., Tempelaar, D., Van den Bossche, P., Gijselaers, W., & Segers, M. (2009). The role of academic motivation in computer-supported collaborative learning. *Computers in Human Behavior, 25*(6), 1195–1206.

Salovaara, H., & Järvelä, S. (2003). Students' strategic actions in computer-supported collaborative learning. *Learning Environments Research, 6*, 267–285.

Schunk, D. H., Pintrich, P. R., & Meece, J. L. (2008). *Motivation in education: Theory, research, and applications* (3rd ed.). Upper Saddle River, NJ: Merrill/Prentice Hall.

Seibold, G. L., & Kelly, D. R. (1988). *Development of the combat platoon cohesion questionnaire*. Alexandria, VA: US Army Research Institute for the Behavioral Sciences.

Sue-Chan, C., Sargent, L. D. The collective efficacy of business students: The role of individual factors and group processes. Paper presented at the Paper presented at the August 1999 National Academy of Management Meetings, 1999, Chicago, IL.

Tai, L. (2008). *Corporate e-learning. An inside view of IBM's solution*. London: Oxford University Press.

Tseng, J. C. R., Hwang, G. J., Tsai, P. S., & Tsai, C. C. (2009). Meta-analyzer: a web-based learning environment for analyzing student information searching behaviors. *International Journal of Innovative Computing, Information and Control, 5*(3), 567–579.

Wang, S. L., & Lin, S. S. J. (2007a). The application of social cognitive theory to web-based learning through netports. *British Journal of Educational Technology, 38*(4), 600–612.

Wang, S. L., & Lin, S. S. J. (2007b). The effect of group composition of self-efficacy and collective efficacy on computer-supported collaborative learning. *Computers in Human Behavior, 23*(5), 2256–2268.

Wang, S. L., & Wu, P. Y. (2008). The role of feedback and self-efficacy on web-based learning: the social cognitive perspective. *Computers & Education, 51*(4), 1589–1598.

Whyte, G. (1998). Recasting Janis's groupthink model: the key role of collective efficacy in decision fiascoes. *Organizational Behavior and Human Decision Processes, 73*(2–3), 185–209.

Widmeyer, W. N., Brawley, L. R., & Carron, A. V. (1990). The effects of group size in sport. *Journal of Sport & Exercise Psychology, 12*(2), 177–190.

Willoughby, T., Wood, E., McDermott, C., & McLaren, J. (2000). Enhancing learning through strategy instruction and group interaction: is active generation of elaborations critical? *Applied Cognitive Psychology, 14*(1), 19–30.

Yager, S., Johnson, R. T., Johnson, D. W., & Snider, B. (1986). The impact of group processing on achievement in cooperative learning groups. *The Journal of Social Psychology, 126*(3), 389–397.

Zaccaro, S. J. (1991). Nonequivalent associations between forms of cohesiveness and group-related outcomes: evidence for multidimensionality. *The Journal of Social Psychology, 131*, 387–399.

Zaccaro, S. J., Blair, V., Peterson, C., & Zazanis, M. (1995). In J. E. Maddux (Ed.), *Collective efficacy*. New York: Plenum.

Zaccaro, S. J., & Lowe, C. A. (1988). Cohesiveness and performance on an additive task: evidence for multidimensionality. *Journal of Social Psychology, 128*(4), 547–558.

Zaccaro, S. J., & McCoy, M. C. (1988). The effects of task and interpersonal cohesiveness on performance of a disjunctive group task. *Journal of Applied Social Psychology, 18*(10), 837–851.