Comparison of 1:1 and 1:m CSCL environment for collaborative concept mapping

C.-P. Lin,* L.-H. Wong† & Y.-J. Shao†
*Graduate Institute of e-Learning Technology, National Hsinchu University of Education, Taiwan
†Learning Sciences Laboratory, National Institute of Education, Singapore

Abstract
This paper reports an investigation into the effects of collaborative concept mapping in a digital learning environment, in terms of students’ overall learning gains, knowledge retention, quality of student artefacts (the collaboratively created concept maps), interactive patterns, and learning perceptions. Sixty-four 12-year-old students from two 6th grade classes (32 from each class) participated in the study. Guided by the methodology of quasi-experimental research, GROUP SCRIBBLES 1.0 was adopted in which students carried out collaborative concept mapping activities for social studies in two different settings: (1) 1:1 (one-device-per-student) – students working in pairs with one Tablet PC assigned to each of them; and (2) 1:m (one-device-to-many-students) – multiple students sharing a Tablet PC. Both settings were evaluated and the interactional patterns of the student groups’ concept mapping were identified. The results indicated that in both 1:1 and 1:m settings, students had improved their learning results and retention. Nevertheless, while 1:1 groups had demonstrated more consistency in group participation, improved communication and interaction, the 1:m groups had instead generated superior artefacts as all the notes were well discussed among the group members. The findings suggest that a higher quality of collaborative processes does not necessarily lead to improved student artefacts.

Keywords
collaborative concept mapping, collaborative learning, computer-aided concept mapping, GROUP SCRIBBLES, meaningful learning.

Introduction
Social Studies is regarded as an integrative subject that applies multiple disciplines of learning concepts and principles to social life (Mintrop 2004). In most of the regular Social Studies lessons in schools, teachers are still giving didactic instructions and employing drill-and-practice routines (see, for example, Kramer-Dahl et al. 2007; Guildry et al. 2010). These tend to be learning outcome-oriented and do not focus on ensuring a deep understanding of what is learnt, often resulting in students overemphasizing the importance of memorizing fragmented knowledge without synthesizing it. This makes learning neither interesting nor effective, and meaningless (Yu et al. 1996). In turns, we conducted a study on incorporating alternative learning design into Social Studies lessons to address this problem. By synthesizing collaborative learning theories and concept mapping, we designed a learning environment for collaborative concept mapping (CCM) activities to support collaboration in competitions and offer more opportunities for discussions and interactions among students. Students were placed into groups and allocated devices in two ways: each student had a Tablet PC in a group [one-device-per-student (1:1)] or each group of students shared only one Tablet PC.
[one-device-to-many-students (1:m)]. We envisioned that different affordances of devices to various groups of students would have affected the collaboration and the learning outcomes, as well as influenced their thinking processes and use of inference in the construction of a concept map.

In this paper, an attempt has been made to seek the answers in 1:1 and 1:m settings to the following research questions:

- Is there any difference in the learning outcomes, learning retention, and the co-constructed concept maps between collaborative concept mapping in 1:1 and 1:m settings?
- Did students in these two settings display different behaviours in their in-group interaction and communication?
- Did students in these two settings differ in their perceptions in and attitudes to the CCM?

Theoretical background

Earlier literature has investigated the advantages of CCM in learning. Previous research on 1:1 digital learning has also shed light on the technology used to enhance concept mapping learning.

CCM

CCM (Roth & Roychoudhury 1994; Hoppe & Gabner 2002; Komis et al. 2002; Basque & Lavoie 2006) is grounded in the synergy of concept mapping and computer-supported collaborative learning (CSCL). In the context of CCM, the target content to be learnt and the target concept map to be constructed are the same across all members within a learning group. Some research suggested that CCM is an effective tool that can lead to synchronous collaboration and effective discussions concerning concepts and thus enhance meaningful learning through a structure of annotations of various levels of abstraction, interpretation, and reflection (Fischer et al. 2002; Avouris et al. 2004). Group members can co-construct a map within the same framework, thus reducing the cognitive load of individual learners (Nesbit & Adesope 2006). Furthermore, through interaction and peer support, each individual continuously appends to and amends the target concept map based on his/her own understanding of the learning content as well as on their judgments of peer opinion.

For each learning group, CCM is a process of collaborative problem solving. During such processes, group members may gain new knowledge from one another. Even though the final maps were the effort of the whole group, it is deemed much more important for all students to have the opportunity to engage in discussion to consider the connections between major concepts from the course. Individual differences in understanding should not be extinguished by this process, but rather should be offered for comparison with other perspectives introduced by students in order to promote conceptual change or consolidation (Kinchin et al., 2005). Previous practices of online CCM environment have reported positive outcomes of enhancing group critical thinking and collaborative problem-solving skills, constructing diagrammatic conceptual representations or sharing solutions into a common space (Fidas & Komis 2001; Komis et al. 2002; Madrazo & Vidal 2002). Researchers found that students could elaborate, refine, and improve their own knowledge structures, using CCM to represent knowledge (Cañas et al. 2003).

1:1 digital learning

The term ‘1:1 digital learning’ was proposed by Cathie Norris and Elliot Soloway (Norris & Soloway, 2002, 2004) and refers to one device (or more) per student for learning purposes. With a variety of affordances offered by wireless mobile computing, information and digital resources can be transferred between devices or stored on the Internet. That opens up endless possibilities of the design and enactment of innovative teaching and learning models (Looi et al. 2010a), ranging from conventional personal computer labs to perpetual and ubiquitous learning (e.g. De Jong et al. 2008; Mifsud & Mørch 2010), authentic and contextualized learning (e.g. Lai et al. 2007; Wong & Looi 2010), seamless learning (e.g. Chan et al. 2006; Roschelle et al. 2007; Looi et al. 2010b), rapid knowledge co-construction (Lin et al. 2008), among others. Furthermore, Chan (2010) points out that we are now at the onset of a digital classroom wave which will bring significant changes to education.

After the initial hype, however, there have been voices within the researcher community to reassess the
notion of 1:1 computing for technology-transformed learning (Looi et al. 2010a), such as whether 1:1 settings may impact peer collaboration and teachers’ roles (e.g. Carlson 2007; Dillenbourg 2010), the issues of student and social readiness (e.g. Wong et al. 2010), as well as the explorations of alternative settings of many-to-one (e.g. Dieterle & Dede 2007), 1:m (e.g. Wong et al. 2009), many-to-many (e.g. Rogers et al. 2010) configurations, or hybrid settings of these configurations (e.g. Liu & Kao 2007). Clearly, each of these computer–student ratios provides different dynamics of interaction and collaboration that support a myriad of learning designs. From the learner’s point of view, the individual herself is the invariant and there needs to be a sense of seamlessness in switching contexts between these different designs (Wong 2010).

In the current study, the Tablet PC was chosen as the learning tool for face-to-face communications, and members of learning groups leveraged on wireless access to interact with each other in the collaborative activities. Nevertheless, as a 1:1 setting (one Tablet PC per student in a group) tended to give individual students greater autonomy in making personal contributions and in editing the group concept map, conceptual or process (such as concurrent mapping) conflicts were often inevitable (e.g. Cheng, Kruger & Daniels 2003). Managing conflicts is always deemed a great challenge in CCM activities (Chiu 2003). The 1:m setting (one Tablet PC per group), on the contrary, is potentially a compromise. A literature scan revealed many studies which compare individual concept mapping and CCM (e.g. Chiu et al. 2000). However, a research gap still exists on the comparative studies between 1:1 and 1:m settings in the context of CCM which the empirical experiment of the current report seeks to fill. It is argued that differences exist in the interaction of group members between these 1:1 and 1:m face-to-face but networked settings for CCM, and a review is presented next on studies of interactional patterns for more insights of group interaction.

The interactional patterns of learning groups

Over the decades, a number of researchers have been seeking ways to categorize interactional patterns in small learning groups, with or without computer support, through their ethnographic studies on their learning activities. In search of an analysis tool to uncover and classify the student group communicative patterns in the study, three relevant frameworks were identified and synthesized, namely, the categorizations proposed by Milson (1973), Roth (1995) and Huang (2001). Milson’s categorization has offered one of the most influential interaction analysis tools for collaborative learning, and recent CSCL studies are still adopting this technique (e.g. Chen et al. 2003; Li & Kao 2007). Examples of recent CSCL studies that adopted Roth’s framework are Li (2006) and Hu and Chiou (2008).

Some parallels can be observed among the categorizations of the three interactional patterns, which were well grounded in their empirical studies and analyses as reported in the respective publications. In the present study, they have been consolidated and mapped into five common patterns (Table 1).

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Ideal</td>
<td>Ideal</td>
<td>Symmetric interaction</td>
</tr>
<tr>
<td>Leader</td>
<td>Dominant leader</td>
<td>Asymmetric interaction</td>
</tr>
<tr>
<td>Tete-a-tete</td>
<td>Tete-a-tete</td>
<td>Shifting symmetric interaction</td>
</tr>
<tr>
<td>Fragmented</td>
<td>Fragmented, cliquish</td>
<td>Parallel occasional interaction</td>
</tr>
<tr>
<td>No participation</td>
<td>Unresponsive</td>
<td>Asymmetric interaction</td>
</tr>
<tr>
<td></td>
<td>Stilted</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Unsocial</td>
<td></td>
</tr>
</tbody>
</table>

Table 1. Consolidation of interactional patterns in small groups.

© 2011 Blackwell Publishing Ltd
Methodology

This study sought to investigate the effects of CCM in a 1:1 digital learning environment, as compared with 1:m. Sixty-four students, aged 11 or 12, from two 6th grade classes (32 from each class) in a primary school in Taichung County participated in the study. They were taught the second unit of the Social Studies lesson, ‘Investment, Financial Management and Economic Activities’, as well as taking a competency pre-test on the subject, prior to the study. Based on their results in the pre-test, a homogeneity test was performed on the two groups of students by classifying them into the following heterogeneous groups.

Students were split into eight ‘1:1 groups’ and eight ‘1:m groups’ with similar numbers of high-, medium-, and low-ability students across the groups to ensure a homogeneous subject matter competency among the groups. Whereas each of the members of the 1:1 group was assigned a Tablet PC to perform CCM, in the 1:m group four students shared one Tablet PC. Sets of quantitative and qualitative data were collected for analysis. The quantitative data consisted of the results of pre-, post-, and postponed-tests, with the ‘N-G score’ (see the section under ‘Research findings and discussion’ for more details) proposed by Novak and Gowin (1984) as the scoring rubric of the students’ concept maps, and a student questionnaire investigating student attitudes to collaborative learning, the usability of the software, and learning by concept mapping. The qualitative data consisted of students’ interviews which sought their perceptions in learning, and video recordings made during the intervention in order to analyse their in-group interaction. All the data were triangulated and the findings were formulated in the nature of 1:1 computer-supported CCM activities.

Computer-supported CCM activities

We adopted GROUP SCRIBBLES (gs) (Chaudhury et al. 2006), a CSCL system developed by SRI International, to conduct small group CCM activities. The typical gs interface presents each student with a three-pane window, as shown in the student’s interface in Fig 1. The lower pane is the user’s personal work area, or ‘private board’, with a virtual pad of fresh ‘scribble notes’ (in the context of concept mapping, each ‘note’ carries a concept) on which the student can draw or type with different colours. Students can use the ‘Link’ function to connect two scribble notes. A scribble can be visible to others by dragging it into the ‘public board’ (or their own ‘group board’) in the upper pane and the entire board can be rearranged if necessary, synchronized across all devices. The reverse drag makes the item private again. Users may interact with public scribbles in a variety of ways, such as browsing their content, repositioning them, or moving one from the public board into their private space. New public boards can be created to support multiple activities or spaces for small groups to work (Looi et al. 2008).

The teacher’s interface has the additional administrator board added in the left window frame, as illustrated in Fig 2. This frame shows the list of the students and the grouping of the students. In the student listing, a green dot means that the student is online while a red dot means that that student is offline or absent. On the top of the pane, the function of the group composition is provided, which facilitates the teacher in changing the composition of the group by simply dragging names from the student list.

Before the learning activity, the teacher explained to the students the essence and the components of concept maps, and facilitated a hands-on activity to become familiar with the gs software and to establish group work skills. The group concept mapping activities encouraged the students to collaborate in building concept maps on the theme of ‘Investment, Financial
Management and Economic Activities’ covered in the Social Studies textbook. Figure 3 depicts the 1:1 and 1:m CCM activities.

During the CCM phase, members of each 1:1 group carried out their discussion and posted ideas or connected various concepts to their Group Board, using their individual Tablet PCs. As they continued to refresh their displays for the up-to-date group concept maps, individual students would instantly raise their thoughts or edit the concept map from their own Tablet PC. Conversely, having only one shared Tablet PC, each 1:m group identified a team member to assume the responsibility of creating and editing the concept map, while the rest provided only verbal opinions.

Data collection

To evaluate and compare the processes and outcomes of group concept mapping in 1:1 and 1:m settings, a data collection plan was executed throughout the course of the study as summarized next.

- Pre- and post-tests: An instrument was developed for the Social Studies competency test on the ‘Investment, Financial Management and Economic Activities’ topic. The instrument consisted of 27 multiple-choice questions and true–false questions, with a total score of 100. The instrument was duly verified and validated through a pilot study and the revision of three teachers.
- Learning attitude questionnaire: The questionnaire was intended to investigate the student attitudes in the CCM activities. The 37-item scale consisted of three components: attitudes in collaborative learning (12 items), the usability of the software (10 items), and learning by concept mapping (15 items). Students responded to a four-point Likert Scale (1 = ‘strongly disagree’, 2 = ‘disagree’, 3 = ‘agree’, 4 = ‘strongly agree’). The questionnaire was administered promptly at the end of the intervention.
- Interviews: Semi-structured interviews were conducted with both groups of students. All the interviews were audio recorded and then transcribed and coded for further analysis and data triangulation.
- Video recordings of the intervention: To ascertain the attitudes of the students and their learning process during the mapping activities, photos were taken and the intervention was filmed; this also helped to investigate the interaction patterns within individual student groups.

Experimental process

- Pre-test (20 min): The paper-and-pencil test was administered in each of the two participating classes in turn.
- gs training (20 min): The teacher introduced to the students the electronic notes, the shared space, and the concept mapping tool to familiarize them with the gs environment. The students then carried out a concept mapping exercise in order to establish their group work skills.
- Group concept mapping phase (80 min): The concept mapping theme was ‘Investment, Financial Management and Economic Activities’. The students generated group concept maps collaboratively, based on their individual understanding of the topic.
- Post-test and questionnaire (40 min): The 20-min post-test was administered promptly at the end of the intervention, which was followed by the administration of the learning attitude questionnaire, which lasted another 20 min.
- Postponed-test (20 min): The 20-min postponed-test was administered 1 month after the end of the intervention in order to assess how well they had retained their learning.
- Student interviews: One-to-one interviews were conducted after the end of the intervention.

Fig 2 Teacher’s interface.
Research findings and discussion

This section presents findings from the study. In this paper, focus has been placed on (1) the analysis of the concept mapping results and (2) qualitative analysis of group interational patterns. We summarize the analyses of the pre- and post-test data and questionnaires next; for more details of these aspects, refer to Lin et al. (2010).

Analysis of the pre-, post-, and postponed-test and questionnaire data

• Comparison of the prior competencies of the students involved in 1:1 and 1:m settings: An independent sample t-test was conducted on their pre-test results, yielding the significance value $P = 0.157 > 0.05$ (Levene test: $P = 0.299 > 0.05$), and indicating that both sets of students had compatible competencies in Social Studies prior to the study.

• Comparison of the learning effects after the intervention: The analysis of covariance test was carried out on their pre- and post-test results and yielded $F = 0.231$, $P = 0.632 > 0.05$ (test of homogeneity of regression slopes: $P = 0.398 > 0.05$), showing that the post-test results between both sets of students were not significantly different.

• Analysis of the intervention feedback questionnaire: Students involved in the 1:1 setting scored significantly higher than those in the 1:m setting in all three subscales (perceptions) of the questionnaire, namely, ‘collaborative learning’ ($P = 0.033 < 0.05$), ‘usability of the software’ ($P = 0.044 < 0.05$), and ‘learning by concept mapping’ ($P = 0.028 < 0.05$).

The analysis of the concept mapping results

As previously stated, an ‘N-G score’ was adopted to grade the students’ group concept maps for further analysis. The scoring scheme is described as follows: (1) one point is awarded for each valid and meaningful link; (2) five points are awarded for each hierarchy in the map; (3) 10 points are awarded for each cross-linking; (4) one point is awarded for each valid example. The total score of a concept map is the sum of the scores earned for these four components.

Table 2 depicts the artefact results (scores) yielded by the two groups, which were very close. However, the standard deviation (SD) of the 1:1 groups was prominently higher than that of the 1:m groups, indicating that

<table>
<thead>
<tr>
<th>Group</th>
<th>Group (No)/scores</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1:1 (1) (7) (3) (4) (8) (5) (2) (6)</td>
<td>42.63</td>
<td>11.49</td>
<td></td>
</tr>
<tr>
<td>1:m (2) (5) (6) (1) (8) (3) (7) (4)</td>
<td>42.25</td>
<td>6.74</td>
<td></td>
</tr>
</tbody>
</table>
the differences among the 1:1 group members were greater. The artefacts created by the groups were compared to find out who scored the highest and the lowest points (Group 1 with 59 points and Group 6 with 26 points); it was observed that Group 1 had produced a more structured concept map, with more appropriate descriptions for the concepts and the links. However, the concept map of Group 6 was deficient in omitting key points and giving colloquial, sentence-style descriptions of the links, which resulted in a lack of structure and many invalid links in the concept map. It was therefore concluded that members of Group 6 needed more training in the method of concept mapping. Figure 4 depicts that the concept maps created by Group 1 is more structured and hierarchical than Group 6 of the 1:1 groups.

In contrast, within the 1:m groups where one Tablet PC was shared in each group, the group members were less likely to interfere with one another in the process of concept mapping. The interactional patterns were more consistent, and so were the quality of their artefacts (which is reflected by smaller differences in their concept mapping scores). It can be argued that the 1:1 groups are likely to generate greater differences in their scores than the 1:m groups.

Furthermore, in the 1:1 setting group, work skills and interactional patterns might have exerted greater influence on their scores compared with those of the 1:m groups. It was observed that a student group with effective group work skills might perform even better in a 1:1 setting – for example, Groups 1 and 7 of the 1:1 groups produced the most organized concept maps with the highest scores (59 and 58, respectively), and the greatest numbers of nodes (37 and 36, respectively). Observations from video records revealed that each member of these groups engaged well in their discussions. The post-interviews also revealed that these two groups had indeed exercised more effective group work skills – for example, a student in Group 7 remarked that, ‘Each member proactively participated, as we followed the leader’s instruction at times, and engaged in discussions at other times’.

However, it was also observed that as all members of the 1:1 groups were at liberty to add new nodes and links, it had nevertheless been difficult for them to anticipate what and when their fellow group members would be posting next. Such virtually synchronous mode of concept mapping might have resulted in relatively disorganized concept maps, as in 1:1 Group 3. In those groups with weaker bonding, members had been interfering or deleting each other’s contributions, causing weak concept map contents and lower scores. For example, the student from 1:1 Group 2 argued that his group had lacked collaborative skills and often interfered with each other’s efforts. He further criticized a team member for deleting other people’s notes without permission, resulting in fewer notes made in their group concept map. Figure 5 depicts the concept maps of 1:1 Groups 2 and 3.

Table 3 presents the amount of notes generated by the 1:1 and 1:m groups. As the 1:1 groups had apparently generated more notes compared with the 1:m groups, it can be argued that by adopting the 1:1 setting, students
would be more proactive in offering opinions and participating in concept mapping. This reasoning tallies with the questionnaire results on ‘attitudes on collaborative learning’, namely, Q8 ‘I think such a learning method has motivated me in expressing my thoughts and opinions to the group,’ that yielded significant difference ($P = 0.041 < 0.05$) in the means between the 1:1 (mean = 3.72) and 1:m groups (mean = 3.41). Furthermore, the $sd$ among the 1:1 groups’ notes ($sd = 0.457$) was greater than that of the 1:m groups ($sd = 0.712$). The reasoning for this phenomenon is similar to the explanation for the greater $sd$ among the scores yielded by the 1:1 groups as compared with the 1:m groups, although the group work skills might have also played a part in this.

Table 4 lists the ‘scoring ratios’, i.e. to divide the scores by the number of notes of all the groups. It shows that the scoring ratios of the 1:m groups are higher than those of 1:1 groups – the lowest scoring ratio yielded among the 1:m groups, 1.76 (Group 2), is higher than those of 1:1 Group 7, Group 1, and Group 6. The implication is that although the mean of the amount of notes from the 1:m groups is less than that of the 1:1 groups by 4, the former set of groups usually held group discussions prior to concept mapping, and therefore their concept maps were more relevant and accurate, resulting in higher scores.

In general, more notes should result in higher scores. Nonetheless, Table 4 seems to suggest otherwise –1:1 Group 6 and 1:m Group 8 are positive and negative exemplars of this. The 1:1 Group 6 posted 24 notes and should have scored around 40 marks by the same standard of 1:1 Group 4 with 23 notes; instead, the group scored the lowest (26) marks, which produced a scoring

<table>
<thead>
<tr>
<th>Group</th>
<th>Group (No)/amounts of notes</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1:1</td>
<td>(1) (7) (3) (6) (4) (8) (5) (2)</td>
<td>24.38</td>
<td>8.467</td>
</tr>
<tr>
<td></td>
<td>37 36 26 24 23 18 17 14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1:m</td>
<td>(2) (5) (1) (6) (3) (7) (4) (8)</td>
<td>20.75</td>
<td>5.651</td>
</tr>
<tr>
<td></td>
<td>29 27 23 23 18 18 14 14</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Group</th>
<th>Group (No)/scoring ratios</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1:1</td>
<td>(2) (8) (5) (4) (3) (7) (1) (6)</td>
<td>1.83</td>
<td>0.417</td>
</tr>
<tr>
<td></td>
<td>2.36 2.22 2.18 1.83 1.77 1.61 1.59 1.08</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1:m</td>
<td>(8) (4) (3) (7) (6) (5) (1) (2)</td>
<td>2.10</td>
<td>0.333</td>
</tr>
<tr>
<td></td>
<td>2.79 2.36 2.11 2.06 2.04 1.89 1.83 1.76</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
ratio of 1.08 – the lowest among all the groups. The concept map of 1:1 Group 6 was examined and it was found that the concept descriptions were colloquial, in sentence style, and failed to capture the key points. Hence, the overall concept map was unstructured and contained many invalid notes.

Conversely, 1:m Group 8 posted 14 notes and scored 39 points (thus yielding a scoring ratio of 2.79), which was superior to 1:1 Group 2 and 1:m Group 4 who scored 33 points, respectively, with the same amount of notes. The concept map of 1:m Group 8 was studied, and it was noted that there was an additional hierarchy in the map (five hierarchies in total, scoring 25 marks, which was five marks more than the previously mentioned two groups, respectively).

In summary, this analysis shows that the mean scores of the 1:1 groups and the 1:m groups were very close. Nevertheless, the 1:1 groups revealed a greater difference among their scores, probably because of the larger influence of the group work skill factor on the results. In contrast, the 1:1 setting resulted in more notes being posted, although not necessarily transforming into higher scores. The video recordings were examined, and it was discovered that some of the notes might have been posted without being discussed beforehand, and may not therefore be valid. However, the 1:m groups held discussions prior to posting notes, thus producing concept maps with greater validity and higher scoring ratios.

Closer observation of the videos of the groups’ collaborative process revealed that most of the 1:1 and 1:m groups had been able to carry out discussions and collaborations smoothly, perform analysis and classification effectively, and give examples on the theme. With the exception of Groups 3 and 6, all of the concept maps of the 1:1 groups were neatly executed and structured. The phenomenon shows that the 1:1 setting would not necessarily result in disorganized concept maps; it is suggested that the groups who scored lower should be able to improve their concept maps by receiving additional instruction in collaborative learning and concept mapping skills.

Another important observation is that although most of the students had been able to demonstrate their knowledge of investment and financial management in their concept maps, their classifying structure and most of the examples raised were based on the textbook content, with the exception of a few groups who managed to extend their concept maps beyond the textbook. In addition, most of the groups did not consider cross-linking – an important activity to achieve scores – in their map constructions, thus no score was earned in this aspect. The possible reasons for this phenomenon are: (1) the time limit for CCM had resulted in the students not being able to incorporate their own concepts beyond the textbook and determine the sets of notes with potential relations of cross-linking; and (2) the students were rarely reminded to note the possibilities of ‘cross linking’ throughout the intervention. The student interviews also revealed that they needed more time to construct their concept maps, as a student from 1:1 Group 3 stated, ‘We would be able to produce a more “complete” concept map should we be given more time to discuss’. To address the problem of the lack of cross-linking, it is therefore advisable to allow students more time for in-depth discussion, as well as further instruction in the skills of observation and reflection.

Analysis of the interactional patterns

One of the major goals of this study was to find out whether there was a significant difference between the interactional patterns of the 1:1 and 1:m groups. An analysis was made of the video recordings and group observation diagrams created, as presented in Table 5, guided by the consolidated categorization of interactional patterns presented in Table 1. In the diagrams, H, M, and L denote high-, medium-, and low-ability students, respectively; the two-way arrow ↔ refers to two-way communication that occurred between two students; and the one-way arrow → denotes one-way communication. No arrow between two students implies occasional or no interaction.

In correspondence with Table 1, four types of interactional patterns were observed in the video records of students’ activities: ‘ideal’, ‘leader’, ‘tete-a-tete’, and ‘fragmented’, occurring during the CCM activities of the 1:1 groups. The most common interactional pattern assumed by 1:1 groups was the ‘ideal’ pattern. Among the three 1:1 groups with the ‘ideal’ pattern, Group 3 and Group 7 performed well (ranked second and third, respectively, among the 1:1 groups in terms of the concept map scores) while Group 6 yielded the lowest score among all 16 1:1 and 1:m groups. This finding was unexpected, which suggested that not all learning in the ‘ideal’ pattern would lead to good learning outcomes.
The reason for this is not clear, but it also indicates that there could be factors other than interactions that influence learning. It may also be connected with their management of intra-group tasks and their organization of discussion, and this needs further investigation.

In contrast, the 1:m groups demonstrated ‘leader’ or ‘fragmented’ patterns but no ‘ideal’ or ‘tete-a-tete’ patterns. The ‘fragmented’ pattern was overwhelmingly popular – seven groups undertook this pattern. Group 1, the only group that followed the ‘leader’ pattern, ranked

---

**Table 5.** The interactional patterns of the 1:1 and 1:m groups.

<table>
<thead>
<tr>
<th>1:1 groups</th>
<th>1:m groups</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ideal</strong></td>
<td>Group 3 (46)</td>
</tr>
<tr>
<td></td>
<td>S10 → S29</td>
</tr>
<tr>
<td></td>
<td>S9 → S36</td>
</tr>
<tr>
<td></td>
<td>S12 → S18</td>
</tr>
<tr>
<td><strong>Leader</strong></td>
<td>Group 1 (59)</td>
</tr>
<tr>
<td></td>
<td>S19 → S6</td>
</tr>
<tr>
<td></td>
<td>S27 → S33</td>
</tr>
<tr>
<td><strong>Tete-a-tete</strong></td>
<td>Group 4 (42)</td>
</tr>
<tr>
<td></td>
<td>S25 → S31</td>
</tr>
<tr>
<td><strong>Fragmented</strong></td>
<td>Group 2 (33)</td>
</tr>
<tr>
<td></td>
<td>S20 → S7</td>
</tr>
<tr>
<td></td>
<td>S28 → S8</td>
</tr>
<tr>
<td></td>
<td>S4 → S12</td>
</tr>
<tr>
<td></td>
<td>S5 → S33</td>
</tr>
<tr>
<td></td>
<td>S26 → S17</td>
</tr>
<tr>
<td></td>
<td>S22 → S10</td>
</tr>
</tbody>
</table>
| The * in 1:m group indicates the student who operated the computer. The numbers in brackets represent their group concept map scores.
fourth among the eight 1:m groups. This indicates that in the pattern of 1:m groups, better interactions also led to more effective learning outcomes. It was apparent that the interactions among 1:m group members were generally not as effective as the 1:1 groups. Isolated students were spotted in those groups, and the intra-group communication was far from ideal. It was observed that most of these isolated students were of low ability whose post-test results did not show significant improvement over their pre-test results. In 1:m groups, therefore, there could be a risk that the individual isolated students who were not engaged in the group work learned very little and might have lost their enthusiasm. This could be a disadvantage for this form of collaborative learning.

Nevertheless, some of these 1:m groups with the perceived inferior interational patterns had instead achieved a higher score for their concept maps than most of the 1:1 groups. Unlike 1:1 groups which often suffered from the interference by group members with one another’s contributions, the dominating 1:m group members were able to become more focused in concept mapping, thus producing concept maps of better quality. However, it can be suggested that members of those groups who demonstrated the ‘fragmented’ pattern might not learn and benefit from one another (some members were left out by the core group of contributors) and therefore their ‘better’ concept maps did not necessarily reflect the collective learning gains for all the members. On the contrary, whereas assuming the ‘ideal’ pattern did not guarantee the delivery of better artefacts for the 1:1 groups, the group members’ level of participation tended to be more balanced and therefore created a more fulfilling learning experience, as indicated by the results of the intervention feedback questionnaire. In this sense, this finding agrees with the argument proposed by Kinchin et al. (2005) based on their paper-based CCM study.

Analysis of student interviews
The constant comparative method inspired by grounded theory (Strauss & Corbin 1990) was applied to code the student interview data; it was divided into three axes, namely:

- Interactional behaviours among students: Students from the 1:1 groups claimed that they were able to participate proactively in discussions and in the CCM activities, as well as helping each other; their levels of collaborative skills were influential to the learning activities. Students from the 1:m groups, conversely, observed that some of their fellow group members did not participate often in the learning activities.
- Student perceptions in learning: Students from the 1:1 groups thought that the learning activities were conducive to boosting group discussion and increasing individuals’ willingness to express their ideas. They found the class enjoyable and engaging.
- Views on concept mapping: The students believed that concept mapping helped them in retaining and understanding the course contents. The strategy could be applied to the learning of other subjects as well as in their daily lives.

Conclusions and recommendations
A Social Studies course emphasizes the skills of synthesis and application. The key to mastery of Social Studies is to move away from conventional rote learning and instead become actively engaged in meaningful learning and knowledge acquisition. In this study, CCM was investigated as an effective method of developing logical thinking and enhancing engagement. Both 1:1 and 1:m settings were implemented and compared, with the following conclusions being drawn:

- Learning outcomes: The analysis of student performances showed that both 1:1 and 1:m settings could improve the students’ results and also demonstrated good retention. Neither setting resulted in significant differences in the improvement of these two aspects. As no control group was involved, it is not the aim of the study in the first place to find out whether computer-assisted CCM will result in better learning effectiveness compared with, for instance, paper-based CCM or individual concept mapping.
- Results of concept mapping: Despite there being little difference in the concept map scores between students engaged in the two settings, the SDs of the 1:1 groups were greater than those of the 1:m groups. According to the analysis, the disparity between the performances among the 1:1 groups could be explained by the greater influence of the levels of group work skill on the effectiveness of their collaborations. Conversely, the statistics show that 1:m
groups yielded higher scoring ratios (1.76 marks per note posted in average) than the 1:1 groups. Although 1:1 groups posted four notes (per group) more than 1:m groups on average, the higher number of notes did not necessarily transfer to higher scores. In 1:1 groups, many of the notes may have been posted without being discussed beforehand, thus they were not necessarily valid. In contrast, most of the 1:m groups made well-discussed notes and were therefore more valid and consistent on theme.

• Interactional patterns: When the interactions of all the student groups’ were analysed, it was discovered that the 1:1 groups had practised four interactional patterns: ‘ideal’ (the most popular), ‘leader’, ‘tete-a-tete’, and ‘fragmented’. The 1:m groups, on the other hand, assumed the ‘ideal’ and ‘fragmented’ (the most popular) patterns but not the other two. It is argued that the 1:1 groups demonstrated better quality interactions compared with those of the 1:m groups, as the former setting facilitated greater autonomy for individual students, thus enhancing their level of participation in collaborative learning. In contrast, there were isolated students in some of the 1:m groups, resulting in far-from-ideal group interactions.

• Student learning attitudes and perceptions: The student interviews and the questionnaires revealed their perception that computer-supported CCM is conducive to enhancing group collaboration and peer support, as well as increasing their interest in the Social Studies subject. Most students believed that concept mapping could be applied to other subjects. Furthermore, they felt that the cs software was easy to learn and could assist them in expressing their views.

Table 6 summarizes the differences between the 1:1 and 1:m settings that were observed in this study.

Informed by the said findings, the following recommendations are offered to educators who are keen to adopt the design of this learning activity. First, if there is insufficient equipment available for student access and therefore the 1:m setting is the only viable option, the teacher is advised to monitor all the student groups to check whether or not any student dominates the Tablet PC or is isolated. To avoid such situations, the teacher may design additional activities or measures in order to train the students in established collaborative management strategies, such as taking turns to use the Tablet PC.
PC. Furthermore, as a compromise solution, we recommend additional projecting equipment or an external monitor for the 1:m setting for all members of each student group to view their work-in-progress concept maps at the same time. Such an arrangement may boost the cost of the learning environment but is still relatively less expensive than 1:1 setting. It is hoped that such an arrangement could reduce the potential problem of students becoming isolated and thereby increase general participation within the groups.

If a 1:1 setting is feasible, the teacher should manage the potential problems of lack of group work skills and inconsistent results of concept mapping by providing additional training in general collaborative strategies and, specifically, CCM and conflict resolution skills with the 1:1 setting.

Finally, in the aspect of the software system, the incorporation of an asynchronous discussion board or database is recommended for storing the students’ concept maps for after-class revision and follow-up discussions, so that student learning and reflections can be extended beyond the classroom hours. Furthermore, we envisage that additional functionalities will be incorporated into the new gs version, namely: (1) a feature for tidying up the visual representations of concept maps, which would be beneficial to student learning and teacher evaluation; and (2) a feature for logging the learning process for the teacher’s own reference, for example, to record the notes posted and deleted by every student. Whereas the first proposed feature is mainly for addressing practical needs, the second one would benefit both the researchers and teachers for analysing students’ CCM processes and identifying their deficiencies in learning or collaborations.

Acknowledgements

This study was supported by the National Science Council, Taiwan (NSC 97–2511-S-134–002-MY3). The authors wish to thank SRI International for providing them with a license to use and adapt the gs software in the present study.

References


and Mobile Technologies in Education 2002, Växjö, Sweden.