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Exploring students' learning effectiveness and attitude in Group Scribbles-supported collaborative reading activities: a study in the primary classroom

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Abstract Improving students' reading comprehension is of significance. In this study, collaborative learning supported by Group Scribbles (GS), a networked technology, was integrated into a primary reading class. Forty-seven 10-year-old students from two 4th grade classes participated in the study. Experimental and control groups were established to investigate the effectiveness of GS-supported collaborative learning in enhancing students' reading comprehension. The results affirmed the effectiveness of the intervention designed. In the experiment group, students' learning attitudes, motivation and interest were enhanced as well. Further analyses were done to probe students' interaction processes in the networked collaborative classroom and different collaboration patterns and behaviours were identified. Based on the findings obtained, implications for future learning design to empower L1 learning were elaborated.

Keywords attitude, collaborative learning, e-picture book, Group Scribbles, reading comprehension.

Introduction

In primary education, the importance of enhancing students' reading comprehension has long been recognized (Alvermann & Earle, 2003). Comprehending a passage, in essence, is active meaning-making process during which multiple levels of cognitive skills are applied (Dole, Duffy, Roehler, & Pearson, l991). To get the utmost from a given passage, besides parsing and processing the linearized linguistic form to obtain the literal meanings, readers also need to read between the lines to make inferences and implications, and to relate the current passage to their prior knowledge and past experiences (Carver, 1973; Pearson & Johnson, 1978; Mayer, 1987). According to the socio-cultural theory, the processes of meaning making can be facilitated through social interactions as distributed understandings can be aggregated and negotiated and multiple perspectives can be explored and examined. This theoretically validates the adoption of collaborative pedagogies where student interactions are pursued in reading classes.

In practice, there is accumulating evidence for the positive role collaborative learning plays in improving students' reading comprehension, enhancing learning

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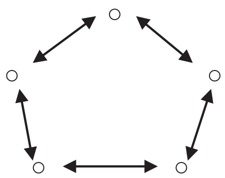
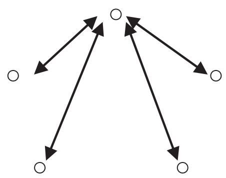
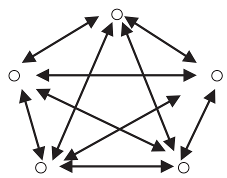
Table 1. Collaboration Patterns (Li, Li, & Lin, 1996)

Type 1	Type 2	Type 3
		
Group answers are of good accuracy.	Task is completed quickly. Group members are least satisfied. Group works well with a strong group leader.	Group members are most satisfied. Task is completed quickly.

motivation and interest, and nurturing positive attitudes (Hakkarainen, Lipponen, & Jarvela, 2002). However, because of physical constraints in traditional classrooms, student interactions are often compromised in both scope and depth. This calls for the introduction of networked technologies accompanied with appropriate pedagogical designs to support and sustain student interactions in real classroom settings.

In this study, collaborative learning activities supported by Group Scribbles (GS), a networked technology co-developed by SRI International and Learning Sciences Laboratory, were designed and implemented in a primary reading class to improve learning. Based on the metaphor of whiteboard and sticky notes for collective construction of knowledge (Roschelle et al., 2007), GS is conceived as a flexible platform for designing and enacting different forms of collaborative work via synchronous communication and interaction in classroom settings (Looi, So, Toh, & Chen, 2011). Previous studies have proved the effectiveness of GS-enhanced group work in improving students' learning outcomes, attitudes and epistemology in various learning contexts, including higher education (Dimitriadis et al., 2007; Looi, Lin, & Liu, 2008), science and math education (Chen, Looi, & Tan, 2010; Looi & Chen, 2010; Chen & Looi, 2011), L2 learning (Chen, Wen, & Looi, 2011; Wen, Looi, & Chen, 2011) and the learning of social sciences (Lin, Wong, & Shao, 2012). Yet, whether GS-supported collaborative learning can bring the same benefits to the L1 classroom is still unclear. This is the very motivation for this study.

Besides exploring learning effectiveness, efforts are also needed to scrutinize student interaction processes in this novel environment and identify the factors that impact learning. Previous studies have found that different patterns of collaboration will emerge in student interactions and prescribe different learning achievements (Milson, 1973; Roth, 1995; Li, et al., 1996). In general, it is agreed that good collaboration is realized via multiple routes of interaction (see Table 1 for the three collaboration patterns identified in small group work). Yet, Li et al. (1996) contends that group composition and group goal exert influence on student collaborative learning outcomes as well. When technology is integrated to support social interactions, the way students collaborate and communicate is undergoing change. Identifying students' collaboration patterns in the networked classroom is of significance as it can inform future pedagogical and technical design. Higher level of discussion is generally associated with the shared interaction pattern (Chung, Lee, & Liu, 2013). Higher quality collaborative processes can improve learning gains and the retention of these learning gains (Lin et al., 2012). Thus, exploring group collaboration patterns was also pursued in this study.

Research method

A quasi-experiment design was adopted to investigate whether GS-supported collaborative learning could bring about improved learning effectiveness in terms of students' scores in the reading comprehension test. In intervention, the experiment class worked collaboratively in small groups (through both face-to-face and GS interaction) to complete the learning tasks designed. The control class carried out the same learning tasks on individual basis. After learning, both classes took a reading test designed by the researcher.

Table 2. Participants' Chinese Test Scores

	Class	No. of participants	*M*	SD	SEM
Chinese test score	Experiment class	24	88.38	7.550	1.54107
	Control class	23	89.63	6.109	1.27390

Table 3. Comparison of Participants' Chinese Test Scores: Independent *t*-test

		Levene's test		*t*		
		F	Significance	*t*	df	Significance (two tailed)
Chinese test score	Levene's test	0.986	0.326	–0.623	45	0.536

Comparative analysis was conducted to see if the experiment class had performed better than the control class. Furthermore, survey and interviews were implemented in the experiment class to explore participants' perceptions of their learning experiences in the networked collaborative classroom. Moreover, natural observations were made to identify the collaboration patterns emerged in different learning groups in the experiment class.

Participants

Two grade 4 classes in a local primary school were involved in this study. In that school, the placement of students into different classes was based on student level test scores. A normal distribution in terms of student L1 proficiency (measured by student level test scores) was pursued. Before intervention, an independent sample *t*-test was administered to examine whether the experiment class and the control class had equal L1 proficiency. As no significant difference was observed ($t_{45} = -0.623$, $p > 0.05$) (Tables 2 and 3), these two classes were considered equally competent in L1.

One class was randomly chosen as the experiment class, the other as the control class. In the experiment class, participants were distributed into small groups, each of four. According to Johnson, Johnson, and Holubec (1990), heterogeneous grouping is the premise for achieving 'cooperative' (collaborative) learning. So in grouping, participants with different L1 proficiency were put into one group. Participants were first divided into three proficiency groups based on their L1 test scores. Then, we randomly chose one participant from the high proficiency group, two from the medium proficiency group and one from the low proficiency group to form a GS group. Altogether, six heterogeneous groups were composed (Figure 1).

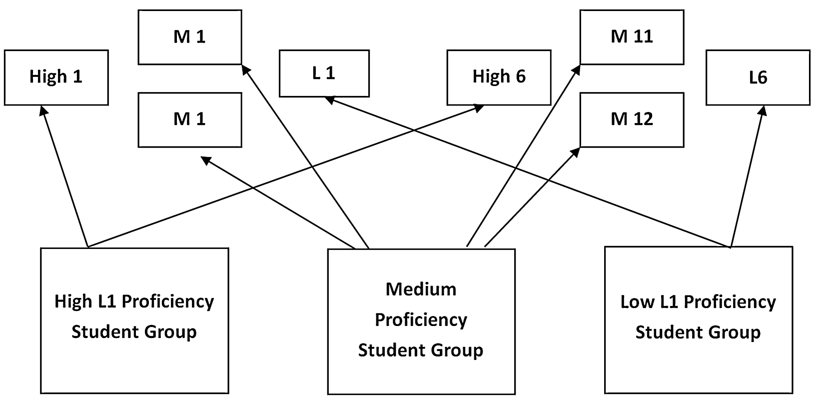


Figure 1 Grouping of Students in the Experiment Class

Pedagogical design

The intervention cycle involved eight lessons (90 min per lesson, 2 lessons per week). The passages covered were from a local textbook and were in accordance with the standard curriculum. The learning materials were presented in the form of an e-picture book incorporated in the GS platform. Three reading activities, namely prediction, connection and summarization, were employed to guide the participants to comprehend the passages (Weaver, 1988; Block, Parris, Read, Whiteley, & Cleveland, 2009; Ko, 2010). In prediction, participants formulated hypotheses about the contents of the following paragraphs in the passage. In connection, participants explored and established relations between phrases, sentences and paragraphs, and related the passages to their prior knowledge and past experiences. In summarization, participants summed up the main idea of each paragraph and/or wrote an abstract for the passage. To help the participants finish these reading activities, in times of real need, the teacher would give demonstrations, explanations, elaborations and clarifications. To ensure the consistency in instruction, lessons in both the experiment class and the control class were delivered by the same researcher (Tables 4 and 5).

GS technology

In the experiment class, the reading activities described above were completed through collaborative group work via face-to-face and GS interaction. Each group was provided a laptop with GS installation (in the control class, each student was provided with a laptop loaded with the e-picture book). GS 2.0 presented the participants with a two-paned interface encompassing a private working area, the 'private board' in the lower section, and a public working area, the 'public board' in the upper section. Participants could generate virtual pads of 'scribbles' on the private board to draw, write and type in their ideas. All the actions performed and contents produced in this area were invisible to others. Scribbles were published and shared as participants dragged them onto the public board, which was synchronized among all learning devices. Scribbles on public board could be removed, repositioned and taken back to the private board for further revision. The e-picture book (designed by the researcher) was embedded into the public board. Before having the reading lessons, the experiment class had undergone one GS technical training session (90 min). It was observed that the participants could use GS with ease after the training (Figure 2).

Data collection

To measure students' learning effectiveness, a reading comprehension test was developed. Ko (2006) divides reading activities into two categories based on the level of processing involved: 1) direct comprehension activities and 2) comprehension through interpretation activities. Following this categorization, three types of questions were constructed in the test: 1) 'Literal' questions (participants directly picked up facts\information from the passage); 2) 'Inferential' questions (participants drew inferences and implications by analysing the literal meanings; and 3) 'Integrated interpretation' questions (participants associated and synthesized information\ideas delivered in the passage, their background knowledge and personal experiences to make meaning). The test contained both multiple-choice questions (including all three types of question) and open-ended questions ('Integrated interpretation' question only).

Initially, 36 questions were constructed for the test. The test was validated by a group of experts on reading comprehension. Cronbach's coefficient α achieved 0.8 in internal consistency reliability test. According to Ebel and Frisbie (1991), the level of difficulty and discriminability of good test items should be between 0.4–0.8 and 0.4–1, respectively. To ensure appropriate difficulty and discriminability, a pilot study involving 72 students from other three classes in the same grade was carried out. Based on the results, improper items were removed. The finalized test consisted of 30 questions (Table 6), each valuing 3 points. For open-ended questions, the score a participant gained was the average of the scores given by two teachers whose ratings were found highly consistent after training. A pretest-posttest design was used in this study. Before having the reading lessons, both groups of participants took the reading test. After intervention, both groups took the same test again (items were presented in a different order). Participant scores in both tests were mined.

Table 4. A Generic Lesson Plan for the Experiment Class

Reading strategy Lesson flow	Predicting	Connecting	Summary
Activity 1	1) Researcher introduced the title of the passage. 2) GS group learning: predicting the story in the passage and generating group hypothesis 1		
Activity 2	1) Participants read paragraph 1. 2) GS group learning: – Modifying group hypothesis 1 – Predicting the development of the story in the following paragraph and generating group hypothesis 2	GS group learning: – Sentence connecting question: filling in appropriate connectors to complete the sentences. – Event connecting question: making connection among the events listed and put them in correct order	GS group Learning: – Summarizing the content of the paragraph
Activity 3	1) Participants read paragraph 2. 2) GS group learning: – Modifying group hypothesis 2 – Predicting the development of the story in the following paragraph and generating group hypothesis 3		
Activity 4	1) Participants read paragraph 3. 2) GS group learning: – Modifying group hypothesis 3 – Predicting the development of the story in the following paragraph and generating group hypothesis 4		
Activity 5	1) Participants read paragraph 5. 2) GS group learning: – Modifying group hypothesis 5		
Activity 6		GS group learning: – Paragraph connecting: answering comprehension questions about the whole passage	
Activity 7			GS group learning: – Writing a summary for the story
Activity 8		1) Participants read the whole story 2) GS group learning: Completing My Story Map	
Activity 9	Individual reflection: Completing My Story Learning Sheet		

GS = Group Scribbles.

To explore the experiment class' perceptions of the collaborative learning experiences in a networked classroom, both quantitative and qualitative data were collected and put into analysis. After the intervention, the experiment class filled in a survey questionnaire in which how this group of participants perceived collaborative learning (three items) and GS-supported collaborative learning (four items for using the GS software and five items for participating in GS learning activities) were examined. A 5-point Likert scale was used in response (1 = *strongly disagree*, 2 = *disagree*, 3 = *neutral*, 4 = *agree*, 5 = *strongly agree*). The higher the score, the more participants agreed with the statement given. The instrument constructed was validated by experts on reading comprehension and e-learning. Before doing the survey, participants were informed that their answers would only be revealed to researchers and honest responses were expected. In addition, in-depth semi-structured interviews were administered to get a better understanding on the issue. Interview participants were identified via random selection. In group interviews (4 participants per group, altogether 2

Table 5. A Generic Lesson Plan for the Control Class

Reading strategy Lesson flow	Predicting	Connecting	Summary
Activity 1	1) Researcher introduced the title of the passage. 2) Individually learning: predicting the story in the passage and generating hypothesis 1		
Activity 2	1) Participants read paragraph 1. 2) Individual learning: – Modifying group hypothesis 1 – Predicting the development of the story in the following paragraph and generating hypothesis 2	Individual learning: – Sentence connecting question: filling in appropriate connectors to complete the sentences. – Event connecting question: making connection among the events listed and put them in correct order	Individual learning: – Summarizing the content of the paragraph
Activity 3	1) Participants read paragraph 2. 2) Individual learning: – Modifying hypothesis 2 – Predicting the development of the story in the following paragraph and generating hypothesis 3		
Activity 4	1) Participants read paragraph 3. 2) Individual learning: – Modifying group hypothesis 3 – Predicting the development of the story in the following paragraph and generating hypothesis 4		
Activity 5	1) Participants read paragraph 5. 2) GS group learning: – Modifying group hypothesis 5		
Activity 6		Individual learning: – Paragraph connecting: answering comprehension questions about the whole passage	
Activity 7			Individual learning: – Writing a summary for the story
Activity 8		1) Participants read the whole story 2) Individual learning: Completing My Story Map	
Activity 9	Individual reflection: Completing My Story Learning Sheet		

GS = Group Scribbles.

groups, 40 min per group), participants were encouraged to articulate and reflect on the way they collaborated in group work. Four Individual interviews were arranged to explore participants' attitudes towards GS lessons and their perceived learning effectiveness. All the interview sessions were videotaped, transcribed and documented.

To understand the way participants collaborated in GS lessons, a video camera was set up in each group to record their interaction processes. Screen capturing software PowerCam (Wondershare TM, Shenzhen, China) was installed in the group laptop to track interaction that occurred throughout the learning activities. Researchers observed each lesson and took down detailed field observation notes and reflection journals. All the videos and PowerCam files were collected, transcribed and combined with field observation notes for analysis.

Results

Learning effectiveness

As indicated in the independent sample *t*-test, no significant difference was observed in participants' scores

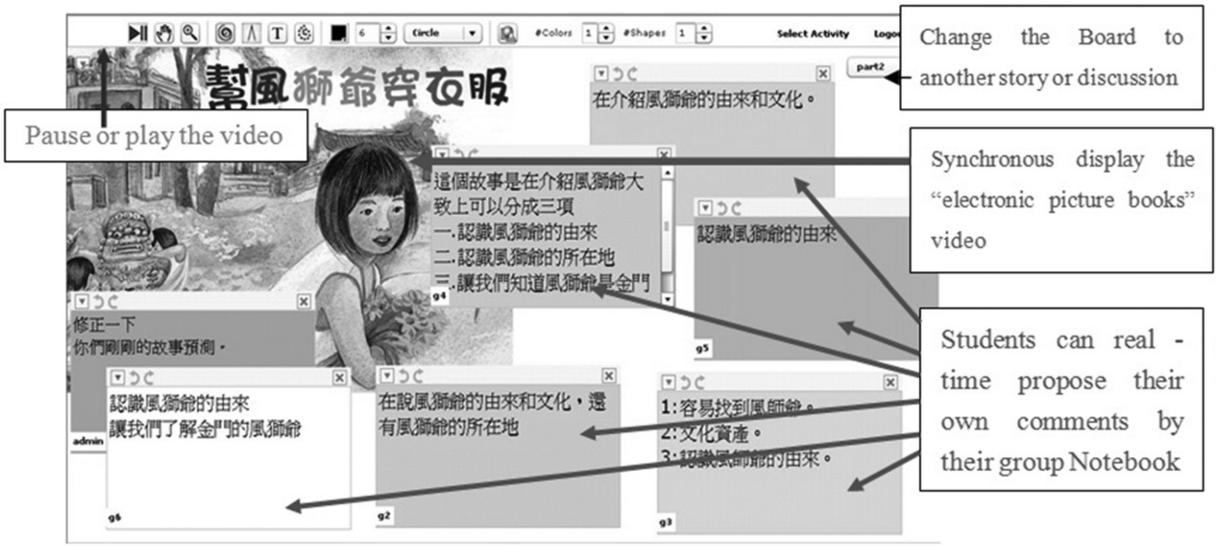


Figure 2 Group Scribbles Interface

between the experiment class and the control class in the pretest ($t = 0.268$ $p > 0.05$, Table 7). A strong correlation between participants' L1 test scores and reading comprehension test scores was identified (experiment class: $r = 0.652$, $p < 0.05$; control class: $r = 0.576$, $p < 0.05$, Table 8). The ratings on the open-ended questions given by the two teachers were also highly correlated ($r = 0.951$, $p < 0.05$).

In comparing the two classes' performances in the posttest, their pretest scores were used as the covariant. The assumptions of analysis of covariance (ANCOVA) were met as the independent variable (GS intervention) and the dependent variable were independent; the latter was linear correlated with the covariant; and the regression coefficients between the dependent variable and the covariant were the same in two classes ($F_{44} = 0.004$, $p > 0.05$, Table 9). Analysis showed that there were differences in the posttest scores between the two classes that could not be explained by the differences in the pretest ($F_{44} = 11.468$, $p < 0.05$, Table 10). Thus, conclusion could be made that GS-supported collaborative learning had improved students' reading comprehension in the primary classroom.

Apart from examining the total score, further analyses were carried out to identify the areas where collaborative learning was most beneficial. The impact of

Table 6. Question Items in Reading Comprehension Test

	All test items	Literal questions	Inferential questions	Integrated interpretation questions
Number of items	30	13	12	5
Degree of difficulty	62.3	72.3	60.9	39.4
Degree of discrimination	0.416	0.380	0.458	0.410

Table 7. Comparison of Participants' Scores in Reading Comprehension Test (Pretest): Independent Sample *t*-test

	Experiment class		Control class			
	M	*SD*	*M*	*SD*	*t*	Significance (two tailed)
Pretest score	44.02	10.945	43.24	8.890	.268	.790

Table 8. Correlation Between Participants' Chinese Test Scores and Reading Comprehension Test Scores (Pretest): Correlation Analysis

	Experiment class				Control class			
Class	*M*	*SD*	Correlation	Significance (two tailed)	*M*	*SD*	Correlation	Significance (two tailed)
Chinese test	88.38	7.550	0.652**	0.001	89.63	6.109	.576**	.004
Reading comprehension test	44.02	10.945			43.24	8.890		

$^{**}p < 0.01$.

question type on collaboration-based learning was investigated. In ANCOVA, scores gained for each type of questions in the pretest served as the covariant. Assumptions for ANCOVA were met as equal regression coefficients between the dependent variable (score gained for each type of questions in the posttest) and the covariant were comparable (literal questions: $F_{44} = 1.058$, $p > 0.05$; inferential questions: $F_{44} = 0.268$, $p > 0.05$; integrated interpretation questions: $F_{44} = 1.169$, $p > 0.05$). After comparison, there was no difference found between the experiment class and the control class in terms of scores gained in 'Literal' questions ($F_{44} = 0.883$, $p > 0.05$) when the differences in pretest scores were excluded. However, participant scores in 'Inferential' and 'Integrated interpretation' questions improved significantly in the experiment class (inferential questions: $F_{44} = 5.518$, $p < 0.05$; integrated interpretation questions: $F_{44} = 26.369$, $p < 0.05$, Table 11). This indicated that GS-supported collaborative learning positively contributed to improving students' reading comprehension, especially in solving 'Inferential' and 'Integrated' questions that required high-order thinking and complex cognitive processing.

Learning attitudes

Attitudes towards collaborative learning

How the participants perceived collaborative learning after experiencing the intervention was an important dimension explored in the survey. As presented in the descriptive data (Table 12), most participants believed they could learn from their classmates in the collaborative work. According to them, collaborative learning was quite effective in enhancing interactions among peers. However, when asked whether they preferred learning collaboratively to learning individually, some were conservative on the issue.

In the interview, perceived benefits from collaborative learning were better elaborated. On one hand, working in a group could deepen and expand one's thinking as the participants could access to a diversity of ideas proposed by others. Just as some participants stated (the interview was conducted in students' L1 Chinese and then translated verbatim into English):

– When learning individually, I couldn't know what others were thinking about, while working in a

Table 9. Participants' Reading Comprehension Test Scores

	Experiment class			Control class		
	M	*SD*	Progress	*M*	*SD*	Progress
Pretest	44.02	10.945	37.56	43.24	8.890	30.08
Posttest	81.58	13.202		73.32	11.705	
Posttest (adjusted)	81.200		37.180	73.715		30.475

Table 10. Comparison of Participants' Scores in Reading Comprehension Test (Posttest): ANCOVA Analysis

Sources	Type III sum of squares	df	MS	*F*	Significance
Class	657.081	1	657.081	11.468	.002
Error	2521.082	44	57.297		

ANCOVA = analysis of covariance.

Table 11. Comparison of Participants' Scores Regarding Different Question Type in Reading Comprehension Test (Posttest): ANCOVA Analysis

Sources	Type III sum of squares	df	MS	F	Significance
Literal questions					
Question type	19.811	1	19.811	0.883	0.353
Error	987.687	44	22.447		
Inferential questions					
Question type	111.307	1	111.307	5.518	0.023
Error	887.618	44	20.173		
Integrated interpretation questions					
Question type	476.109	1	476.109	26.369	0.000
Error	793.647	44	18.037		

ANCOVA = analysis of covariance.

group; I could refer to others' ideas and think more.

- (In group work) when stuck on a question, I could refer to the answers proposed by others and then think for myself.
- It took a long time to come up with the solution solely by myself. However, when we worked together in a group, we could quickly find a solution.
- (In group work) if I don't know how to answer the question, I can refer to the answers proposed by others and further improve them if needed.
- It is easier to work in a group because your work load is lessened.

On the other hand, collaborative learning increased participants' confidence in their answers as these answers were based on group collective wisdom:

- We first discussed and then put up the answers.
- In my group, we first presented our individual answers, and then discussed which answers were better. . . . The final answer was the combination and integration of our individual thoughts.
- We summarized and synthesized ideas from all group members. Our answer was the integration of our individual thoughts.
- In my group, the more competent ones would give their ideas first, and then we had group discussion. . . . we got more support and companionship in group work.

Attitudes towards GS-supported collaborative learning

To measure participants' attitudes towards GS-supported collaborative learning, their perceptions about using the GS software and participating in GS learning activities were examined, respectively. Data collected revealed that participants in general held positive attitudes towards the GS technology (Table 13). GS made group discussion easier, provided more opportunities for airing opinions, and enabled

Table 12. Descriptive Statistics of Participants' Attitudes Towards Collaborative Learning ($N = 24$)

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	M
1) I can learn from my classmates in collaborative learning.	10 41.7%	7 29.2%	5 20.8%	2 8.3%	0	4.04
2) In collaborative learning, the interaction among students is enhanced.	7 29.2%	8 33.3%	9 37.5%	0	0	3.92
3) I prefer learning in groups to learning individually.	8 33.3%	5 20.8%	7 29.2%	1 4.2%	3 12.5%	3.58

Table 13. Descriptive Statistics of Participants' Attitudes Towards Using GS in Group Collaboration ($N = 24$)

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	*M*
1) It's easy to discuss using GS.	13 54.2%	8 33.3%	3 12.5%	0	0	4.42
2) I have more chances to express my opinions using GS.	7 29.2%	9 37.5%	7 29.2%	1 4.1%	0	3.92
3) It's easy to access to others' opinions using GS.	12 50%	7 29.2%	5 20.8%	0	0	4.29
4) I learned better using GS than in the traditional classroom.	8 33.3%	10 41.7%	6 25%	0	0	4.08

GS = Group Scribbles.

quick access to others' ideas, which, in turn, helped the participants learned better.

Furthermore, most participants found GS a convenient and stable platform for discussion because synchronous communication and sharing of ideas could be achieved on GS. The generic configuration of the technology also made improvised discussion a reality.

– In traditional classes, we used whiteboard for group discussion and we needed to clean the board. Using GS, we didn't have to do the cleaning work. We could organize our discussion quickly.

With regard to participants' perceptions of GS learning activities, the overall picture was quite encouraging. GS activities helped them better understand the passages and increased their learning interests. Most participants preferred GS learning activities to traditional ones and would like to continue the experience in the reading class and further extend it to classes on other subjects (Table 14).

Data collected in interviews also indicated that GS activities leveraged participants' interests in learning, as can be seen in the following statements.

– It's quite boring that you sit alone and wait for teacher's instruction. . . . I like learning in this way.
– I like this way of learning.
– I think GS activities were interesting.

Collaboration patterns

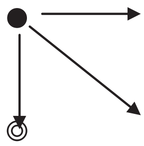
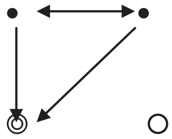
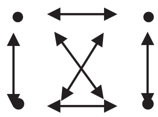
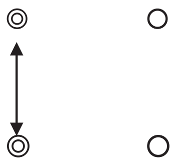
One of the major goals of this study was to find out the interaction patterns in group work. Analysing group video recordings and group observation diagrams mined, three collaboration patterns were identified in the experiment class (Table 15). In the table, two-way arrows refer to two-way communication that occurred between two students; one-way arrows denote one-way communication. No arrows imply occasional or no interaction.

Table 14. Descriptive Statistics of Participants' Attitudes Towards Participating GS Activities ($N = 24$)

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	*M*
1) This way of learning is better than the traditional one.	14 58.3%	7 29.2%	3 12.5%	0	0	4.46
2) I liked to learn in this way.	10 41.7%	11 45.8%	3 12.5%	0	0	4.29
3) I understand the reading materials better from discussions.	9 37.5%	7 29.2%	6 25%	1 4.2%	1 4.2%	3.92
4) I hope I can learn other subjects in this way.	16 66.7%	5 20.8%	3 12.5%	0	0	4.54
5) I would like to have more reading classes like this.	9 37.5%	11 45.8%	4 16.7%	0	0	4.21

GS = Group Scribbles.

Table 15. Collaboration Patterns Emergent in GS Lessons

Collaborative pattern	Collaboration process	Communication and computer control • Computer controller ◎ Other group member ○ Excluded group member	Group
Group with strong leader(s)	1) The group leader(s) (highly competent student\students) controlled the computer and guided the group working process while other members simply followed the leader(s). 2) Quick in coming up with the answers 3) Irrelevant posts would appear as the group leader(s) played with functions of GS	 One group leader  Two group leaders (taking turns to control the computer and working collaboratively)	G1  G4 
Group with equal participation	1) Group members distributed the work and took turns to control the computer. Every member enjoyed equal opportunities and contributed to group work 2) Slow in coming up with the answers 3) No excluded group member 4) Abundant group discussion	 Group members took turns to control the computer. If one encountered difficulty, others would help.	G2; G5; G6 
Fragmented group	1) No one was willing to control the computer in the group. 2) Lacking in confidence in solving the questions; answers being rough and raw 3) Scarce group discussion 4) Some members being excluded		G3 

GS = Group Scribbles.

As indicated in the narrative and visual data, participants were found shouldering different roles in group work. Highly competent participants usually served as group 'leaders'. They often dominated the group work and initiated group discussions. They were also the ones who always controlled the group learning device. As these 'leaders' were very concerned with self-efficacy, they often rushed to post their opinions on the public board. And these actions often silenced other group members. Furthermore, they voluntarily

Table 16. Comparison of Participants' Scores in Reading Comprehension Test: Pair-Wised *t*-test

Collaborative pattern	Group	Pretest *M*	Pretest SD	Posttest *M*	Posttest SD	*t*	Significance (two tailed)
Group with one strong leader	G1	45.69	10.098	79.56	12.250	−18.425	0.000
Group with two strong leaders	G4	43.00	20.804	81.00	22.636	−21.496	0.000
Group with equal participation	G2	40.44	6.839	86.13	7.758	−16.976	0.000
	G5	45.44	9.718	84.44	16.291	−7.491	0.005
	G6	48.00	6.367	84.94	7.928	−13.031	0.001
Fragmented group	G3	41.56	12.161	73.44	11.736	−8.375	0.004

explored the functions and features of GS during breaks in group work. On the contrary, there were also the ones who were completely excluded from group interaction. These 'outsiders', usually low-ability students, lacked both the competency and interest in participating in group discussion and negotiation. Most students were found either too active or passive in group work. They did engage in group work and make their contributions to the group work. But their actions were usually in response to requirements and encouragements from the group 'leader'.

Although different groups communicated and interacted in different manners in the learning process, all groups progressed significantly in the posttest as indicated in the pair-wised *t*-test (Table 16). But the progress of 'Groups with Equal participation' and 'Group with two strong leaders' improved more than 'Group with one strong leader' and 'Fragmented Group' did.

Discussion

This paper reports the integration of GS-supported collaborative learning into a primary reading class for 8 weeks and explores participants' learning effectiveness achieved, learning attitudes established and collaboration patterns emerged in this learning experience.

That collaborative learning can bring about improved learning effectiveness in the reading class has been substantiated as the experiment class performed significantly better than the control class in the reading test. This agrees with previous research findings concerning the impact of collaborative learning on improving students' reading comprehension (Hollingsworth, Sherman, & Zaugra, 2007; So & Brush, 2008; Murphy, Wilkinson, Soter, Hennessey, & Alexander, 2009; Spörer, Brunstein, & Kieschke, 2009). In group work, ideas from multiple perspectives can be generated, aggregated, synthesized and further improved. During this process, students' understanding on the topic can be continuously reorganized and reconstructed (Hewitt & Scardamalia, 1998), all good to the development of both knowledge and thinking skills.

The processes of collaborative idea improvement can be facilitated by the integration of networked technologies. GS, the technology incorporated, provides students with a favourable environment where ideas were going through constant evolution (Chen et al., 2010). With GS, students can better express and extract ideas as it allows for paralleled processing. This can address the problem of production blocking (Suthers, 2006) that plagues in face-to-face interaction, and for anonymous participation that enables the pooling of a diversity of ideas and the evaluation and critiquing of existing ideas. As ideas published can be taken back for further editing, meanings constructed can be enhanced in both depth and width. Unlike verbal talk that is of temporal logic, texts on the virtual media are persistent and can mediate the following meaning-making activities (Ritella & Hakkarainen, 2012). From the observations made, the necessity of providing dual interactional spaces to accommodate both individual preferences and contextual particularity to empower multi-modal meaning making in collaborative learning scenarios has been revealed.

Apart from improving learning outcomes, GS-supported collaborative learning also helped build positive learning attitudes and enhance students' learning interests and confidence. Instead of being passive recipients of information as in the traditional didactic instruction, students are active agents in collaborative learning, contributing ideas and information for the construction of group understanding. During this process, they will become more responsible and take more initiatives in their own and group learning (Zhang, Scardamalia, Reeve, & Messina, 2009).

From class observation, different collaboration patterns and learning behaviours have been identified. That students varied in language proficiency, interpersonal and communication competencies, collaborative skills and prior knowledge and experiences on the topic might account for this phenomenon. Previous studies have proved the effect of grouping on the process of collaboration (Johnson & Johnson, 2000). When heterogonous groups are composed, group discussion and working process are likely to be dominated by those highly competent students, putting less competent students in a disadvantageous position. The unequally distributed participation of students prescribed by their discrepant language proficiencies was also noted in this study. Furthermore, that students held different understandings about collaborative learning was probably another factor. As some were still in favour of individual learning as indicated in the survey (probably due to the long exposure to individually based classroom instruction and assessments), their motivation in participation in group learning might not be that strong, which could negatively impact the group dynamics. Ng, Looi, and Chen (2008) also point out that students with perfectionist streak or shy personality is the possible reason of their being silent in class. Yet, regardless of these individual differences, as long as the students were engaged in group work, they would benefit from this learning experience as indicated in our study. From these observations, the necessity of practicing collaborative pedagogies in classrooms to improve learning is better unveiled. The significance of designing and developing appropriate collaborative scaffolds (e.g., scripts) to encourage student participation and interaction is also highlighted. As the forming of collaborative cultural is a long-term process, continuous efforts should be made to enhance students' commitment to the collaborative work.

It should be pointed out that this study only investigates a limited group of students in a specific learning context. Any generalization or application of the research findings should be done with caution. In the following, investigations involving larger populations in different L1 learning scenarios (e.g., composition) are to be conducted. With accumulating learning design experiences on networked technology-supported collaborative learning, pitfalls and progresses throughout the journey are to be mined and documented as well. This in turn will inform the development of design principles for collaborative learning for language learning that can be translated into a broader spectrum of contexts.

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References

Alvermann, D., & Earle, J. (2003). Comprehension instruction. In A. P. Sweet & C. Snow (Eds.), *Rethinking reading comprehension* (pp. 12–30). New York, NY: Guilford.

Block, C., Parris, S., Read, K., Whiteley, C., & Cleveland, M. (2009). Instructional approaches that significantly increase reading comprehension. *Journal of Educational Psychology*, *101*(2), 262–281.

Carver, R. P. (1973). Reading as reasoning: Implications for measurement. In W. H. MacGinitie (Ed.), *Assessment problems in reading* (pp. 44–56). Newark, DE: International Reading Association.

Chen, W., & Looi, C. K. (2011). Active classroom participation in a Group Scribbles primary science classroom. *British Journal of Educational Technology*, *42*(4), 676–686.

Chen, W., Looi, C. K., & Tan, S. (2010). What do students do in a F2F CSCL classroom? The optimization of multiple communications modes. *Computers & Education*, *55*(3), 1159–1170.

Chen, W. L., Wen, Y., & Looi, C. K. (2011). Technology and pedagogy design for collaborative second language learning. *Communications in Information Science and Management Engineering*, *1*(8), 18–21.

Chung, C.-W., Lee, C.-C., & Liu, C.-C. (2013). Investigating face-to-face peer interaction patterns in a collaborative Web discovery task: The benefits of a shared display. *Journal of Computer Assisted Learning*, *29*(2), 188–206.

Dimitriadis, Y., Asensio, J. I., Hernandez, D., Roschelle, J., Brecht, J., Tatar, D., . . . Patton, C. (2007). From socially-mediated to technology-mediated coordination: A study of design tensions using Group Scribbles. *Computer Supported Collaborative Learning 2007 Conference* (CSCL 2007), New Jersey, USA.

Dole, J. A., Duffy, G. G., Roehler, L. R., & Pearson, P. D. (1991). Moving from the old to the new: Research on reading comprehension instruction. *Review of Educational Research*, *61*(2), 239–264.

Ebel, R. L., & Frisbie, D. A. (1991). *Essentials of educational measurement* (5th ed.). Englewood Cliffs, NJ: Prentice Hall.

Hakkarainen, K., Lipponen, L., & Jarvela, S. (2002). Epistemology of inquiry and computer-supported collaborative learning. In T. Koschmann, R. Hall, & N. Miyake (Eds.), *CSCL 2: Carrying forward the conversation* (pp. 129–156). Mahwah, NJ: Lawrence Erlbaum.

Hewitt, J., & Scardamalia, M. (1998). Design principles for distributed knowledge building processes. *Educational Psychology Review*, *10*(1), 75–96.

Hollingsworth, A., Sherman, J., & Zaugra, C. (2007). *Increasing reading comprehension in first and second grades through cooperative learning* (Unpublished MA thesis, Saint Xavier University & Pearson Achievement Solutions, Chicago).

Johnson, D. W., & Johnson, F. P. (2000). *Joining together: Group theory and group skills*. Boston, MA: Allyn & Bacon.

Johnson, D. W., Johnson, R. T., & Holubec, E. J. (1990). *Circle of learning: Cooperation in the classroom*. Edina, MN: Interaction.

Ko, H. W. (2006). *The reading literacy of fourth grade students in Taiwan*. PIRLS. Retrieved May 10, 2012, from http://lrn.ncu.edu.tw/pirls/PIRLS%202006%20Report.html

Ko, H. W. (2010). *Handbook of instruction on reading comprehension strategy*. Taiwan: MOE.

Li, M. X., Li, M. H., & Lin, Z. H. (1996). *Organizational behavior*. Taipei: Yang-Chih.

Lin, C. P., Wong, L. H., & Shao, Y. J. (2012). Comparison of 1:1 and 1:m CSCL environment for collaborative concept mapping. *Journal of Computer Assisted Learning*, *28*(2), 99–113.

Looi, C. K., & Chen, W. (2010). Community-based individual knowledge construction in the classroom: A process-oriented account. *Journal of Computer Assisted Learning*, *26*(3), 202–213.

Looi, C. K., Lin, C. P., & Liu, K. P. (2008). Group scribbles to support knowledge building in jigsaw method. *IEEE Transactions on Learning Technologies*, *1*(3), 157–164.

Looi, C. K., So, H. J., Toh, Y., & Chen, W. (2011). The Singapore experience: Synergy of national policy, classroom practice and design research. *International Journal of Computer-Supported Collaborative Learning*, *6*(1), 9–37.

Mayer, R. E. (1987). *Educational psychology: A cognitive approach*. New York, NY: Harper Collins.

Milson, F. (1973). *A introduction to group work skill*. London, England: Routledge and Kegan Paul.

Murphy, P. K., Wilkinson, I. G., Soter, A. O., Hennessey, M. N., & Alexander, J. F. (2009). Examining the effects of classroom discussion on students' comprehension of text: A meta-analysis. *Journal of Educational Psychology*, *101*(3), 740–764.

Ng, F. K., Looi, C. K., & Chen, W. (2008). Rapid collaborative knowledge building: Lessons learned from two primary science classrooms. In P. A. Kirschner (ed.), *International perspectives in the learning sciences*, *Proceedings of ICLS*, Utrecht, The Netherlands.

Pearson, P. D., & Johnson, D. D. (1978). *Teaching reading comprehension*. New York, NY: Holt, Rinehart and Winston.

Ritella, G., & Hakkarainen, K. (2012). Instrumental genesis in technology-mediated learning: From double stimulation to expansive knowledge practices. *International Journal of Computer-Supported Collaborative Learning*, *7*(2), 239–258. doi:10.1007/s11412-012-9144-1

Roschelle, J., Tatar, D., Chaudhury, S. R., Dimitriadis, Y., Patton, C., & DiGiano, C. (2007). Ink, improvisation, and interactive engagement: Learning with tablets. *Computer*, *40*(9), 42–48.

Roth, W. M. (1995). *Authentic school science: Knowing and learning in open inquiry science laboratories*. Dordrecht, The Netherlands: Kluwer Academic Press.

So, H. J., & Brush, T. A. (2008). Student perceptions of collaborative learning, social presence and satisfaction in a blended learning environment: Relationships and critical factors. *Computers and Education*, *51*(1), 318–336.

Spörer, N., Brunstein, J. C., & Kieschke, U. (2009). Improving students' reading comprehension skills: Effects of strategy instruction and reciprocal teaching. *Learning and Instruction*, *19*(3), 272–286.

Suthers, D. D. (2006). A qualitative analysis of collaborative knowledge construction through shared representations. *Research and Practice in Technology Enhanced Learning*, *1*(2), 1–25. Retrieved from http://scholarspace.manoa.hawaii.edu/handle/10125/2613

Weaver, C. (1988). *Reading process and practice*. Portsmouth, NH: Heinemann.

Wen, Y., Looi, C. K., & Chen, W. (2011). Towards a model for rapid collaborative knowledge improvement in classroom language learning. *Proceedings of 8th International Conference on Computer Supported Collaborative Learning (CSCL 2011)*, pp. 836–851, Hong Kong.

Zhang, J., Scardamalia, M., Reeve, R., & Messina, R. (2009). Designs for collective cognitive responsibility in knowledge-building communities. *Journal of the Learning Sciences*, *18*(1), 7–44.