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GROUP SCRIBBLES TO SUPPORT "FRACTION" COLLABORATIVE LEARNING IN A PRIMARY SCHOOL

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The study focused on exploring the effects of the performance and attitude in learning fraction concepts by using CSCL. Fifty-five 9-year-old students from two Grade 3 classes participated in the study. Experimental and control classes were established to investigate the effectiveness of GS-supported collaborative learning in enhancing students' fraction learning ability. The Group Scribbles (GS 2.0) software was used to support this collaborative learning activity for the experimental class. The statistical analysis of test and questionnaire indicated that the CSCL learning design had positive effects on the learning effectiveness and learning retention. The GS-based learning combined with collaborative learning has shown the significant popularity among the students. Quasi-experiment study confirmed the positive role of student collaboration in empowering learning and improving student perceptions. Using GS software, group members relied on and helped with each other. This could elevate the students' motivation and concentration in learning.

Keywords: CSCL; fraction; Group Scribbles; primary education.

1. Introduction

Concept learning of mathematics is one of the major challenges for students in primary schools. The concept of "fraction" is particularly difficult to be grasped (Hunting, 1983).

Math educators have made great efforts to identify the effective pedagogies that can help students learning that concept (Streefland, 1991). Mathematics learning is considered a very important and core subject. Among all the approaches proposed, collaborative learning is gaining increasing favor. This constructive pedagogical approach underscores promoting peer-peer interactions and authentic problem solving in mathematical knowledge/concept construction and practicing learning activities that are organized around the students (Liu, 1996). This learner-centered pedagogy has been practiced in various contexts to improve mathematics learning and has produced remarkable results (with enhanced learning effectiveness, promoted learner motivation, interest and efficacy, improved attitude and epistemology) (Johnson & Johnson, 1996).

In this research, an experiment study was conducted to investigate whether the learning infrastructure (Lipponen & Lallimo, 2004) constructed would cultivate enhanced learning effectiveness and improved attitudes. We try to achieve the following:

(1) To propose the model problem the effectiveness of GS-based collaborative problem solving to improve students' fraction learning.
(2) To explore real-time sharing and group discussions with GS to facilitate collaborative learning.
(3) To explore the CSCL activities with GS software to stimulate students' attitudes in mathematics learning.

2. Literature Review

2.1. *Fraction learning*

Fractions, though being difficult and complex to learn as claimed by many researchers, are still one of the main topics in the lower and upper primary mathematics syllabus (Yusof & Malone, 2003). Grade 3 children in Taiwan have to understand Equal Distribution, Simple Fractions, Fraction Unit, Equivalent Fractions, and Fraction Calculation (Addition & Subtraction). They are taught the fraction topics formally from Primary 3 to Primary 6. In most of the routine math lessons in schools, generally teachers are still practicing didactic instructions, drill and practice, and continuous assessments. Children not only make errors in computing fractions but also hold misunderstandings of the basic concepts.

2.2. *Group Scribbles-supported collaborative learning*

Group Scribbles 2.0, a network technology co-developed by SRI International and Learning Sciences Lab in Singapore was used in this study. Established on the metaphor of whiteboard and sticky notes for collaboration knowledge construction (Roschelle et al., 2007), GS has been identified as an effective and flexible tool for collaborative activity design and enactment in classrooms (Looi, So, Toh, & Chen, 2011). GS presents users with a two-paned interface including a private working area (the "private board" in the lower section) and a public working area (the "public board" in the upper section) (Figure 1). Participants could generate virtual pads of "scribbles" on the private board to draw,

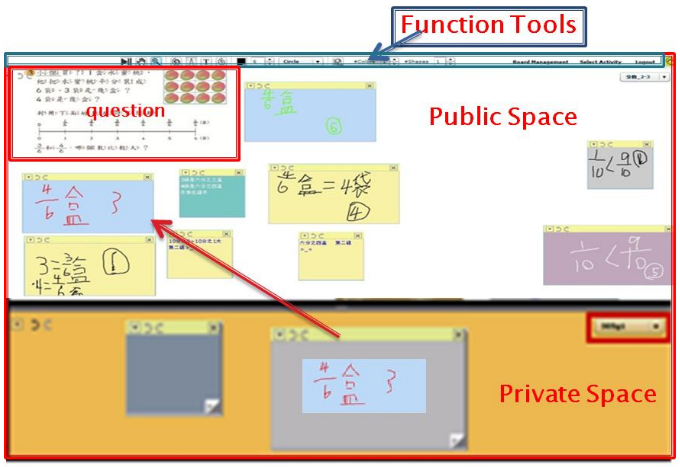

Figure 1. Group Scribbles interface.

write and type in their ideas. All the actions performed and contents produced in this area were invisible to others. When students drag scribbles onto the public board which is synchronized among all the learning devices, they are published and shared. The essential feature of GS technology is the synergy of autonomous cognition (on private board) and collaborative cognition (on public board). Pictures, templates, audio and video clips can be inserted on the public board to better accommodate individual users' needs. To facilitate teacher supervision and facilitation, an Interactive Whiteboard was placed in front of the whole class.

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 math classroom is still unclear. This is the very motivation for this study.

3. Research Method

A quasi-experiment design was adopted to investigate whether GS-supported collaborative learning could bring proved learning effectiveness in terms of students' scores in the fraction ability test. In intervention, the experimental class worked collaboratively in small groups (through both face-to-face and GS interaction) to complete the designed learning tasks. The control class carried out the same learning tasks but without GS. After learning, both classes took a fraction test designed by the researcher. Comparative analysis was conducted to see if the experimental class had performed better than the control class did. Besides, survey and interviews were implemented in the experimental class to explore participants' perceptions of their learning experiences in the networked collaborative classroom.

3.1. *Participants*

Two Grade 3 classes from HsinChu city, Taiwan had been chosen to participate in this study. We randomly selected one class as the experimental class (27 students) and the other as the control class (28 students). The two lessons were delivered by the same teacher. The control class received traditional lecture-based/didactic instruction. In the experimental class, the 27 students were distributed into six groups (three of four students each and three of five students each). Students with different math competence (indicated by student math test scores) were put into one group as heterogeneous grouping, which was proved more beneficial to learning compared to homogenous grouping (Salvin, 1987).

3.2. *Pedagogical design*

Six math lessons were designed and implemented to achieve the learning objectives prescribed in the concept of "fraction" module. In the experimental class, Student Teams Achievement Division (STAD) (Slavin, 1987) was adopted as the main method of collaborative pedagogy design. In STAD, students are assigned to four- or five-member learning teams. The teams are composed of high, average, and low performing students, and of boys and girls. There are five main steps a teacher should follow when STAD is implemented. The teacher presents a new lesson and then students work within their teams to master the lesson. Individual quizzes are taken on the material studied. Students' quiz scores are compared to their own past averages, and points are awarded on the basis of the degree to which students meet or exceed their own earlier performance. The teacher then combines the scores to create team scores. Members of the winning team are given rewards in order to encourage the collaborative learning. In the experimental class, one group was provided with one Tablet PC and shared display. A typical GS lesson consisted of six steps (Figure 2): 1) proposing the model problem (teacher); 2) collaborative problem solving (intra-group); 3) discussing and sharing collective solution (inter-group & teacher); 4) summarizing and consolidating learning points (teacher); 5) extended practice: collaborative problem solving (intra-group); 6) rewarding (teacher). In contrast to GS lessons where students interactions were highlighted, lessons designed for the control class were based on teacher lecturing: 1) introducing learning points (teacher); 2) collaborative problem solving (intra-group); 3) explaining and elaborating the learning points (teacher); 4) extended practice (individual student).

3.3. *Data collection*

To measure students' learning effectiveness, a test was designed by the researcher. There were 13 items of three question types which tap on students' understanding of Equal Distribution, Simple Fractions, Fraction Unit, Equivalent Fractions, Fraction Calculation (Addition & Subtraction) (which are the learning objectives for fraction learning in Grade 3) in the test. Previous research pointed out that the difficulty level and discriminability level of good test items should between 0.4-0.8 and 0.4-1 respectively (Ebel & Frisbie, 1991). The items we developed had met the "good" item standard (average difficulty = 0.65; average discriminability = 0.45). To evaluate learning effectiveness, in the first two rounds of testing, identical test items were used and presented in different orders. In the delayed test, test items with equal difficulty and discriminability were employed.

To explore the experimental 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 control class and experimental class filled in a survey questionnaire in which how students perception of learning gain (four items) and collaborative learning promoted students' engagement in learning (four items). And using the GS software for participating in GS learning activities (three items) were examined. A 5-point Likert scale was used (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. Apart from student learning outcomes, student perception of the learning experiences also serves as an important indicator of learning effectiveness. In this study, a survey questionnaire was constructed to collect data.

To understand the way the participants collaborated in GS lessons, a video camera was set up in each group to track their learning processes. Screen capturing software PowerCam was installed in the group laptop to record their results and interaction 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. After the whole curriculum, data were collected in interview from the instructor, in order to figure out the difference of traditional and experimental teaching.

4. Results

4.1. *Learning effectiveness*

4.1.1. *Pre-test analysis*

As indicated in the independent sample t test (Table 1), there was a significant difference between student scores in the experimental class and those in the control class, the latter

Table 1. Comparison of student scores in pre-test: Independent sample t test.

	Experimental class		Control class		t	Sig. (2-tailed)
	Mean	SD	Mean	SD		
Pre-test score	49.56	24.63	71.46	21.00	-3.541	0.001**

***p<0.01*

outperformed the former (t = -3.541, p = 0.001 < 0.01). This result showed that the control class students were much more competent in fractions compared to the experimental class students.

The two groups differed in pre-test score in math. In order to exclude this factor, the pre-test score was adopted as the covariate in the ANCOVA analysis to investigate the score variance due to the experimental intervention. The Pearson correlation analysis results (p = 0.000, r = 0.613) showed a positive correlation between the pre-test scores and the post-test scores.

4.1.2. *Post-test analysis*

In analysis, a pairwise t test was performed to investigate whether students had progressed after having fraction lessons. Significant improvement was observed in both the experimental class (t = -7.710, p = 0.000 < 0.01) and the control class (t = -3.558, p = 0.001 < 0.01) (Table 2). In the following, ANCOVA (student pre-test score being the covariant) was employed to examine whether discrepancy existed between the two classes. Data analysis denied the hypothesized difference (F = 3.136, p = 0.052 > 0.01) (Table 3).

Table 2. Comparison of student scores in pre-test and post-test: Pairwise t test.

	Pre-test		Post-test		t	Sig. (2-tailed)
	Mean	SD	Mean	SD		
Experimental class	49.56	24.63	76.40	13.25	-7.710	0.001**
Control class	71.46	21.00	80.23	13.86	-3.558	0.001**

***p<0.01*

Table 3. Comparison of student scores in two classes in post-test: ANCOVA.

Class	Type III SS	df	MSS	F	Sig. (2-tailed)
Adjusted Model	1071.243 [a]	2	535.622	3.136	0.052
Pre-test	30981.127	1	20981.127	181.405	0.000**
Class	11.869	1	11.869	0.069	0.793
Error	8880.774	52	170.784		

***p<0.01*

4.1.3. *Delayed-test analysis*

Comparison of student scores in the post-test and delayed post-test scores showed the experimental class not only retained their learning but also achieved a significant improvement ($t = -4.882$, $p = 0.000 < 0.01$) while the control class remained the same with the post-test ($t = -0.270$, $p = 0.789 > 0.01$).

4.1.4. *Score rate of Fraction Concept*

Further analysis of students' score in different types of questions was shown in Table 5. Experimental class students had progressed better on Equal Distribution and Fraction Calculation and retained the learning better than control classes on Simple Fractions questions. However there was no significance with regard to the improvement of unit quantity, showing that the concept of unit quantity was still in need of enhancement. Although the lesson mainly focused on the instruction of addition and subtraction, the result showed that there was a significant improvement in students' understanding of the division, simple fraction, unit quantity, and equivalence. The experiment proved that the continuous communication between students assisted their thinking and concept clarification and their test scores were enhanced accordingly.

Table 4. Comparison of student scores in post-test and delayed test: Pairwise t test.

	Post-test		Delayed-test		t	Sig. (2-tailed)
	Mean	SD	Mean	SD		
Experimental class	76.40	13.25	84.96	9.60	-4.882	0.000**
Control class	80.23	13.86	81.11	10.02	-3.558	0.001**

$^{**}p<0.01$

Table 5. Score rate of Fraction Concept.

Fraction concept	Item no.	Score rate (%)					
		Pre-test		Post-test		Delayed-test	
		Experimental	Control	Experimental	Control	Experimental	Control
Equal Distribution	I、1 I、3	55.5	85	68.5	91	94.5	93
Simple Fractions	I、2	56	75	67	86	81	79
Fraction Unit	I、4、 5、6	44.7	51.7	53	52.3	54.3	37.7
Equivalent Fractions	I、7	56	75	70	68	81	75
Fraction Calculation	II、III	48.7	73.3	87.8	87.7	93.8	94.0

4.2. *Student perception in fraction*

Apart from student learning outcomes, student perception of the learning experiences also serves as an important indicator of learning effectiveness. Comparison of student scores in the two classes was achieved via independent sample t test.

4.2.1. *Student perception of learning gains*

In the questionnaire, four items probed into students' perception of their gains in the learning process. Data collected showed that the students in the experimental class in general were more confident about their learning effectiveness (Table 6). Through class collaboration, students believed they had gained mastery over fraction calculation (adding and subtracting fractions with common denominator). However, students who received more teacher instruction were less on this issue.

4.2.2. *Student perception of learning engagement*

Whether students were actively engaged in the learning activities was another important dimension explored in our survey. Data mined from four items revealed that collaborative learning promoted students' engagement in learning. Compared to the control class, students in the experimental class were more involved in interactions with the teacher, the textbook and other learners in the environment.

Table 6. Comparison of student perception of learning gains.

Items	Class	M	SD	Sig.
I have learned how to add fractions with common denominator.	Experimental class	5	0	0.005**
	Control class	4.61	0.69	
I have learned how to subtract fractions with common denominator.	Experimental class	5	0	0.003**
	Control class	4.54	0.74	
I have learned how to compare fractions.	Experimental class	4.85	0.77	0.218
	Control class	4.61	0.69	
I feel more confident about learning math.	Experimental class	4.81	0.56	0.049**
	Control class	4.43	0.84	

$^{**}p<0.01$

Table 7. Comparison of student perception of learning engagement.

Items	Class	M	SD	Sig.
I participated in all the learning activities and expressed my ideas.	Experimental class	4.96	0.19	0.025*
	Control class	4.68	0.61	
I listened carefully to the teacher's instructions.	Experimental class	4.89	0.32	0.007**
	Control class	4.5	0.79	
I listened carefully to my classmates' opinions.	Experimental class	4.93	0.27	0.016*
	Control class	4.57	0.69	
I worked on the problems listed in the textbook with full concentration.	Experimental class	4.93	0.27	0.007**
	Control class	4.5	0.79	

$^{*}p<0.05$ $^{**}p<0.01$

4.2.3. *Student reflections on GS-supported collaborative learning*

After intervention, students in the experimental class were required to reflect on their group learning process on the virtual platform. Analysis of student notes showed that in general students held positive attitude toward GS-supported collaborative learning. The benefits students mined in this novel leaning environment include: 1) students could improve communication skills; 2) students could enhance negotiation and coordination skills; 3) learning interest, efficacy and motivation could be promoted; and 4) students could develop good relationships with other classmates.

With regard to technology use, most students found GS was easy and beneficial to use (Table 8). After initial training, students could attain certain proficiency in using GS. And the integration of GS made classroom collaboration easier.

Table 8. Student reflection on GS.

Items	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	M	SD
I know how to use GS.	92.6	7.4	0	0	0	4.93	0.27
With GS, I can easily see others' ideas.	88.9	7.4	0	0	3.4	4.78	0.8
It is easy to learn in computer-supported classrooms.	88.9	11.1	0	0	0	4.89	0.32

4.3. *Learning process analysis*

The aim of cooperative learning is to increase students' learning efficiency by peer interaction and collaboration. Figure 2 shows that the teacher needed to control the

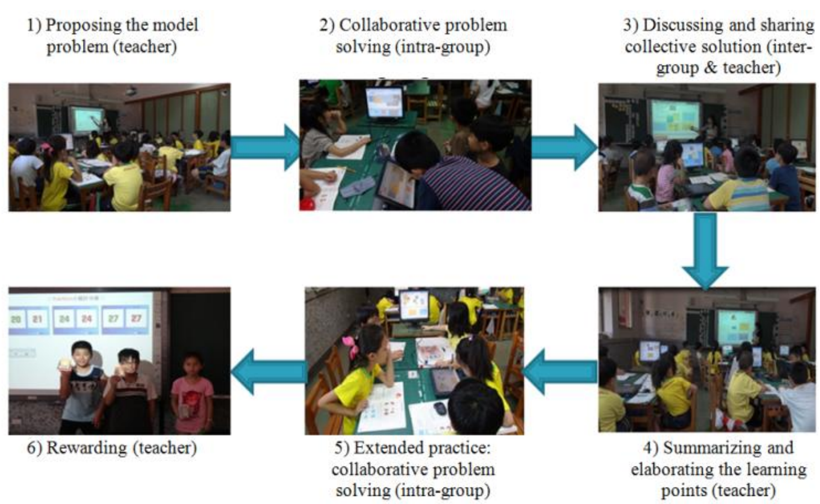

Figure 2. Learning activity processes.

progress for students' participation. Although group discussion was usually active, the students with lower abilities in each group had difficulty to follow the group discussion and were willing to adopt other group members' opinions to avoid being corrected by others or making mistakes that might influence group performance. Therefore, the teacher needed to encourage students to build trust and collaboration, obtain group achievement by group communication, and learn the main points. The group situation was chaotic at the beginning. There was less argument and more harmony and efficient group discussion after the first two lessons. The collaborative learning approach was interesting to students, and the inter-group competition impelled students to accomplish the mathematics topics, interaction and participation in the class.

With the Tablet PC and shared display, groups' thought and opinions could be instantly sent back via the discussion and display provided by the GS software. There was more practice opportunities for students with the provision of the active textbook contents made by the interactive media, vivid mathematics teaching content through the interactive teaching materials, and randomly transformed examples. Students had the opportunity to learn from group members, rather than passive learning from teachers. Using GS software, group members relied on and helped with each other. The group learning activities results are shown in Figure 3.

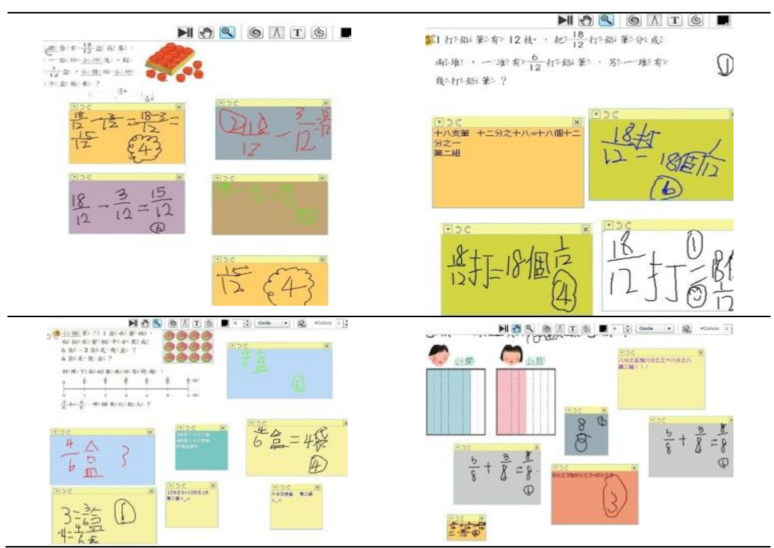

Figure 3. Results of the activity.

4.4. *Teacher's voice*

After delivering the whole curriculum, the instructor pointed out the lessons learned from the traditional and experimental teaching.

(1) Teaching preparation: The experimental teaching required more preparations than the traditional teaching did. For example, it would require a lot more time on teaching materials preparation, network testing, hardware testing, grouping and process design.
(2) Classroom predominance: The traditional teaching method was easy to control with little unexpected situation and students were used to the passive learning method, although being lack of interaction. The computer-assisted cooperative learning model was more attractive to students. They were fascinated with "learning by discussion". However, there were more unexpected situations compared to the traditional teaching methods and the instructor should be able to control the situation and the teaching progress. The instructor also needed to have the abilities to deal with the hardware problems.
(3) Student performance: The computer-assisted cooperative learning model required students to follow instructors' instructions, questions, perform the discussions within the groups and present the results via the GS system. During the group cooperative learning process, the learners would try their best to finish the tasks not only for the individual results but also for the group results. The results showed the learners from experimental classes were positive and focused in learning compare with traditional learning groups.
(4) Hardware application: It was of no difficulty for the Grade 3 students. The majority of learners had showed great enthusiasm for computing. Applying the CSCL design transformed their preferences to learn mathematics. It would have the positive implications if the teaching contents and hardware devices were well coordinated.

5. Discussion and Conclusion

GS-supported group work has positive effects on student learning effectiveness. Though GS experimental class did not outperform the control class in the post-test, they did not underperform as well though their competence in fractions had been much lower than the control class before the intervention. More importantly, their improvement in mathematics concepts not only retained but also progressed. That progress was not observed in the control class where there was little peer collaboration but substantial teacher instruction. In the experimental class, students could communicate and discuss their ideas with ease and comfort. When being immersed in a pool of diverse ideas, students can interact with multiple perspectives, and their thinking is always being reorganized and reconstructed (Hewitt & Scardamalia, 1998), which cultivates cognition of improved scope, depth and precision, all good to cognitive development.

Apart from inducing enhanced learning effectiveness, collaborative group work could also improve student perceptions of the learning experiences, enhancing motivation, interest and confidence of students. Compared to the control class, students who were involved in group work reported higher participation and engagement in the learning activities. They were also more satisfied with and confident about their learning gains. In a collaborative classroom, students are no longer passive recipients of "knowledge" but active agents for knowledge consolidation and construction. When students shoulder the role of knowledge maker, they will take more responsibility and initiatives for their own and group learning. Using GS software, group members relied on and helped with each other. This elevated the students' motivation and concentration in learning.

Concept learning is really a challenge for students in primary schools. However, teachers can employ specific pedagogies to engage students and help them construct the concept. From our investigation, collaborative learning is found beneficial to fraction learning in primary classrooms. However, considering the scope and specificity of the present study, we should be cautious when applying the findings to other scenarios.

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