

# Peer Explanation in Primary Mathematics Learning

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**Abstract:** This study aims at proposing a feasible classroom activity which can introduce math knowledge by systematically scaffolding students to figure the new concept out and then construct their own logics and thoughts by written and oral language. A three-step learning flow, including puzzle-solving, writing to learn, and peer explanation, is proposed in this study. To investigate the fundamental theoretical issues and possible obstacles, this learning flow was initially implemented in a fourth-grade classroom without technology supports. In the initial stage of this study, this paper focuses on discussing the effectiveness of peer explanation and some observations in this learning activity.

**Keywords:** scaffolding, peer explanation, elementary mathematics learning

## 1. Introduction

Over the past decades, learning-by-being-told has been the major learning activity in elementary mathematics classrooms. Typically, when a new topic begins, teachers will introduce the main ideas, demonstrate some examples, ask some questions, and then has students practice individually or in groups—if enough time is left. However, the concept presented by teachers or textbooks may differ from students' perception when students are passively accepting messages. Even though they can gain new procedural knowledge from such kind of instruction, students may still don't understand the concept behind.

This study aims at proposing a feasible classroom activity which can introduce math knowledge by systematically scaffolding students to figure out the new concept and express their understanding by written and spoken words. A three-step learning flow is proposed in this study, including puzzle-solving, writing-to-learn, and peer explanation. Among these steps, the former two are conducted individually, while the last step is designed as dyad interaction. Each step has its theoretical fundamental to be addressed. And preliminary experiment was conducted to discuss the learning flow.

## 2. Literature Review

Research has shown that students can benefit from learning by explanation. Chi, Bassok, Lewis, Reiman and Glaser [2] indicated that by self-explanation, students reconstructed and summarized their learning process. Such explanation includes explicating the meaning of solution steps or extrapolating the consequence of solution steps so that deeper understanding can be achieved [3][5]. It is also known that, on the other hand, explaining to others had positive influence on learning [6] [9] [13]. This is because learners monitor their own misunderstanding and knowledge gap when they are explaining.

However, explanation doesn't work unless the explainer provides higher order thinking while explaining. In the research of self-explanation, it was found that no significant difference between the learning outcomes of learning material description and read-only condition [8]. Chi [4] also demonstrated that deep explanation, including knowledge building, reflection, and inference, is the key factor of successful learning by explanation. In a study of peer questioning and explanation, King [10] used high-level question stems as scaffolds and found that such stems could produce better explanations and learn more effectively. Besides, in tutor-tutee learning, tutors learn effectively when explaining ideas and responding questions, especially when their answers provided reflective knowledge-building [1] [11]. In some studies, explanation is more completed when explaining to others—for making the idea understandable by others [12]. In the research of peer instruction [7], students submit individual answers first and then try to convince each other by explaining their reasons. In this process, students apply the core concept just presented by the class teacher. It also involves every student in the class, instead of some smart students able to answer the teacher's questions, and is proved to be an effective approach for large class.

### 3. Learning Flow Design

The proposed learning flow is illustrated in Figure 1; the upper layer denotes student action, and the lower layer indicates the scaffolding from the learning materials or peers. This flow is a hybrid of individual and peer learning. In the first and second steps, two scaffolds--graphical representation and written language--are provided to help students learn new concept individually. In the third step, peer explanation is taken for providing oral language scaffolding by peer conversation.

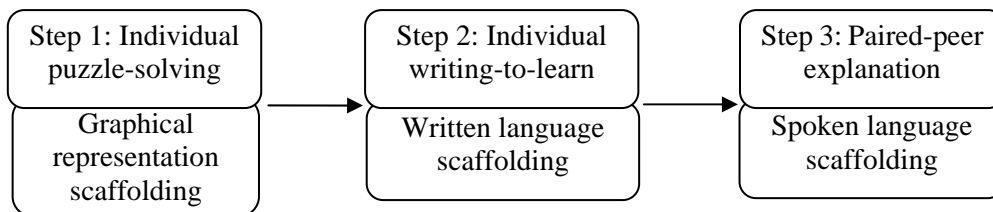


Figure 1: peer explanation learning flow

In step 1, students have to solve some puzzle-like math questions. The puzzles are designed as graphical illustrations and gradually guide students to solve them individually. To do so, initially some worked examples are provided, and then a number of similar expressions with missing symbols or numbers appear. According to their observation from previous examples, students are forced to think which number or symbol should be filled in, and then gain implicit knowledge about the main concept in those puzzles.

In the second step, short essay questions about the target concept are asked. At beginning answers with incomplete sentences are provided to guide students to fill in key phrases about the target concept. Questions are designed to let students summarize procedure knowledge and elaborate conceptual understanding. Serving as a deep explanation facilitator, such writing-to-learn design helps students to gain further understanding about the target knowledge.

Finally it is the oral language scaffolding. Two students get together to mutually explain about those questions they answered in the second step. In this stage, students help each other to learn by giving spoken language scaffoldings. By making their thoughts externally and encountering peers' feedbacks, students get chances to clarify, confirm, and repair the newly built knowledge in the previous two steps.

#### 4. Experiment and Results

One research question of this study is, based on the proposed learning flow, whether the third step—peer explanation—can benefit students more than the former two steps so that the necessity of the design of peer explanation can be confirmed.

The subjects were 34 fourth-grade pupils, including 19 boys and 15 girls. They were divided into two groups. According to the independent-sample t test of subjects' math score of last semester, there was no significant difference between two groups ( $p=.986>.05$ ). Nine boys and nine girls were allocated in the experiment group, while ten boys and six girls were in the control group.

There were two conditions compared. The experiment group went through all the three steps in the proposed learning flow, while the control group only experienced the first and second steps. That also means the students in the control group learned individually, while the others had the chance to learn collaboratively. To eliminate the time difference, the questions given to the control group were more than the experiment group, so that both groups had to finish their tasks in about the same time—40 minutes.

The target concept in the learning materials is distributive law. Both procedural and conceptual knowledge were tested in the pre- and post tests. In the procedural knowledge assessment, students were asked to complete an expression of distributive law, such as  $5 \times (8 + 2) = ( \_ \times \_ ) + ( \_ \times \_ )$ . As for the conceptual test, students had to exemplify the distributive law on their own. The pre-test result showed that none of the subjects know about distribution law. And the results of the post-test are demonstrated in Table 1. The percentage represents the portion of subjects who did the test correctly. Both groups' performance on procedural assessment significantly increased from pre-test to post-test, but no significance exists between the two groups ( $X^2=.289>.05$ ). On the other hand, subjects' performance on the concept understanding was significantly different between the two groups ( $X^2=.042<.05$ ).

Table 1: Results of post-test in distributive law context

	procedure	Concept
Experiment group	88.89%	81.25%
Control group	75%	37.5%

#### 5. Discussion

The result in Table 1 implies that puzzle-based scaffolding and writing-to-learn may be good enough to have students individually learn how to perform an arithmetic procedure. It shows that three-fourths of subjects in the control group could individually learn how to carry out the procedure. When the chance of peer interaction is provided, the number of portion may be raised even higher. However, the results obviously show that puzzle-based scaffolding and writing-to-learn could not lead to a better concept understanding if subjects were not involved in peer interaction. Therefore, in the following of this section, the observations from peer explanation in the experiments are reported.

In order to realize what really happened during the peer explanation, all the subjects' dialogs were recorded during the experiments. In those discourses, three main forms which benefit student learning were found, including self knowledge repairing, consistency reaching, and peer tutoring. Some dialogs are selected as examples in the following.

##### Dialogue 1: Self knowledge repairing

*Student A: ...then add the two numbers.*

*Student B: Is it 13 plus 7? But why add these two numbers? Oh, I got it!*

Student A was trying to explain how to the distributive law work. Student B followed his partner's explanation by asking a more specific question. But instead of waiting the further explanation from student A, student B figure it out by himself. It demonstrated that peer interaction can stimulate students to re-think the implicit knowledge previously learned, the knowledge that they may not completely understand or there are some small gaps they didn't find out. Then such stimulation can help them repair their knowledge gaps and then gain more understanding about the knowledge.

#### Dialogue 2: Knowledge consolidation through reaching consistency

*Student A: My answer is different from yours.*

*Student B: Where?*

*Student A: I'm going to calculate it again. (Student B watched student A recalculating.) (A few seconds late...) Look! Your answer is wrong here. Our answers are different.*

Dialogue 2 demonstrates an example of peer learning by reaching consistency. Because the proposed learning flow requires students provide their individual answers and then share them with their partner, students may find the difference between their original answers and try to resolve the conflicts. In this case, student A was not sure about her own answer when she found her partners' was different. However, this pushed her to check her work, and such action helped her to consolidate her knowledge. After gaining the same answer, she became more self-confident and pointed out where her partner made a mistake. Therefore her partner, student B, also learned from the demonstration of her re-calculation.

#### Dialogue 3: Peer tutoring—tutoring by guidance

*Student A: You think first, and then write.*

*Student B: (Speaking while writing) Addition of 2 and 8 equals to 10, and then multiply 10 by 15... It's 150!*

*Student A: See, Don't you feel this method is quicker to get answer? (comparing with the speed of  $2 \times 15 + 8 \times 15$ —a hint on the learning material)*

*Student B: Yes!*

Dialogue 3 is about peer tutoring. It was the most common finding in the pairs composed by a higher achiever and a lower one. In dialogue 3, student A tried to guide her partner to find out which calculation strategy was better than the other. In this case, peer explanation is similar to tutor-tutee interaction. High-level students summarize their knowledge so that their partner can learn. The most important of all is that that lower level students also have to explain to the other, so their understanding can be monitored and they can also benefit from oral explanation.

## 6. Conclusion

Based on the findings discussed in this paper, it is suggested that, with appropriate design of learning flow and its associated materials, students can build new knowledge by themselves, instead of being told by others—teachers, parents, elder peers. Such a message is very important not only because it is well known that knowledge can retain better if it is figure

out by the learner, but also because in a classroom, the teacher can save more time for individual needs while others are learning by their own.

This research has shown that puzzle-based scaffolding and writing to learn together can let students learn new procedures, and that peer explanation help student learn new concept. However, it is not clear yet that how much the puzzle-based scaffolding and written language scaffolding can benefit students respectively, neither can this paper prove that the proposed approach can be more effective than the conventional teacher-led classroom instruction. This paper only presents the feasibility of the proposed learning flow and investigates the possible effect from peer explanation.

The next step is implementing the proposed learning flow with technology to provide more supports, such as real-time responds, easy to control learning flows and adaptive scaffolding. Then investigating such implementation in the classroom to find out what works in practice, and then further revision will be made. Such process may be iterated many times. Along with this process will be more comprehension about how technology can change the practice in classrooms, how teachers can help students more, and how students' learning can be improved—cognitively and affectively.

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