Children's Algorithmic Sense-making through Verbalization

Hajime Shirouzu (shirouzu@sccs.chukyo-u.ac.jp)
School of Computer and Cognitive Sciences, Chukyo University
Toyota, Aichi 470-0393 JAPAN

Introduction

This paper demonstrates the effectiveness of children's own verbalization on their conceptual understanding of why they do what they do to solve a simple arithmetic problem. The problem was solvable by the interaction with the external resources, and the externalized answers could be described verbally as they were seen. Verbalization, however, in its essence, could include talker's own interpretation or explanation of the externalized records (Pine & Messer, 2000; Shirouzu, Miyake & Masukawa, 2001).

I conducted a small-case learning experiment, asking six sixth-graders in a class to cut out the 3/4 of 2/3 of the origami paper's area. They were of roughly same performance on the math and had already mastered the fractional multiplication. Initially, all of them manipulated the paper directly to solve the task. Yet, gradually guided by a teacher-experimenter, through multiple collections of the solutions and explicit comparisons among them, four students actively worked out why the answer was equal to the one-half of the whole and finally verbalized its algorithmic solution (2/3X3/4=1/2). Six months later, these students described the task by mentioning its algorithmic aspect as "devising various ways to make the one-half area," but the remaining two could not do so even though they also gave explicit consent to the algorithmic solution proposed at the end of the lesson. I hypothesize that the key to the individual differences is in their verbalization on how they interpreted own externalized solutions, differences or similarities among peers' solutions, and the task itself.

Learning Setting

The data come from a 6th grade classroom in a remote branch school of Japan, which had six students (2 girls, 4 boys) as a whole. I visited there twice as a teacher-experimenter to conduct a lesson and make a follow-up inquiry, both of which were recorded by videotape for analyses.

There were three intended phases in the lesson, to make students solve the problem and explain their solving steps, to have them reflect upon the differences or similarities among solutions, and to ask them why the goal area was constant as one-half. For the first phase, I prepared sheets of origami paper, a pencil, and a pair of scissors, and then asked them a problem. Every time the student presented his answer, I accepted it and made him explain to all how he made it with visualizing solving processes by extra origami papers. For the second phase, I let the students compare each two solutions chosen from what they had made. For the third phase, I asked what was common among all answers and why it was.

Six months later from the lesson, I visited the class again with the inquiry: "Please write down anything that you remember about what happened at the last lesson."

Analysis

Overall, the performance of this class "appears" to be quite high. Everyone solved the given task actively and correctly. Newer interpretations were frequently made and easily shared under "one voice." Hidden by such seemingly one voice, however, crucial differences in their understanding occurred through chances of verbalizing their own interpretations.

If a student replied to the question about the sameness of the answers as, "They are the same not in form but in area," instead of only as, "Different," I coded that he verbalized more than what was seen actually. When the others only consented to such interpretation, I defined that they did not take initiative of explicit verbalization. In this way I coded what child mentioned what interpretation. Although space prevents me from describing the entire shifting-process of interpretation, the interpretations they made and articulated in the lesson appeared in their reports in the follow-up inquiry clearly.

Child 1, for example, answered to why all the solutions were the same as, "If I multiply these two fractions, we can see the answer in the frame of the whole, which equals one-half. So, all of these are equal to the one-half of original." In the following-up, he tied his experience of using origami to the fractional multiplication. On the other hand, Child 2 consented vigorously to Child 1's explanation above, but answered to the inquiry, "I remembered two-thirds and three-fourths," which reveals his remembrance of fragmental facts. Child 3 explained her solving step of the second try as, "If a part of the rest (1/4 of 2/3) of my first answer is combined with this area (1/3), I can get three folded rectangles. This (the answer, 3/4 of 2/3) has also the three rectangles. So if I folded the paper into the half of six parts, the three-sixths, I thought that I could make the 3/4 of 2/3." Even though this early reference to the one-half-ness could not be shared among others, she was explainable at the end of the lesson why the answer was one-half based on her diagrammatic understanding, which could be also recognized in her following-up report.

The result implies that the students who verbalized their interpretations could produce durable abstract understanding. This proposes a protest to the lecture style instruction in which a teacher delivered well-structured explanations and students are only silent. Instead, we have to make careful analyses on each student's talk and trigger finer interactions to promote the externalization of their own explanations, ultimately to let them deepen their learning by themselves.

References

Pine, K. J., & Messer, D. J. (2000). The effect of explaining another's actions on children's implicit theories of balance. Cognition and Instruction, 18, 35-51.

Shirouzu, H., Miyake, N., & Masukawa, H. (2001). Cognitively active externalization for situated reflection. Submitted to Cognitive Science