YOUNG JAPANESE CHILDREN'S SUBJECTIFICATION AND OBJECTIFICATION THROUGH THE LENSE OF JOINT LABOR

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The article reveals how the processes of subjectification and objectification proceed in a mathematical activity at a Japanese preschool and how the roles of finger gestures change for children during these processes. The theoretical construct used was joint labor as proposed by Luis Radford throughout his work. We relied in part on his methodology and in part on a microgenetic approach to analyze a scene of addition involving children and a teacher in a Japanese preschool. The analysis captured children obtaining help from the teacher to reconstruct the meaning of fingers as tools for solving quizzes rather than preserving the meaning through unprompted practice. The analysis also showed that the role of finger gestures was reconstructed in class to solve a conflict between children's differing solutions to an addition problem.

INTRODUCTION

In recent decades, studies examining young children's mathematical abilities and skills in various areas from a constructivist point of view have accumulated (e.g., Duncan et al., 2007; Lin, Tsamir, Tirosh, & Revenson, 2013). Some have investigated children's gestures during geometrical problem-solving (Elia & Evangelou, 2014; Elia, Hadjittoouli, & van den Heuvel-Panhuizen, 2014). Moreover, socio-cultural issues, which are not intensively discussed in constructivist research on young children, have been examined in the context of research on preschool children in recent studies (Dijk, Oers, & Terwel, 2004; Radford, in press), drawing attention to the socio-cultural nature of the early development of mathematical abilities. Gestures, as well as other embodied actions with verbal languages, were regarded by Radford (2012), as the integral part of children's cognitive functioning. From this point of view, the purpose of this paper is to reveal finger gestures' mathematical roles, especially in the context of socio-cultural settings. To explore such roles, we refer to Radford's theoretical construct of joint labor (2016a, 2016b) and analyze Japanese preschool children's mathematical behaviors from a socio-cultural perspective. The Japanese Ministry of Education, Culture, Sports, Science and Technology's Course of Study for kindergartens (2017) does not explicitly define school subjects, including mathematics, and expects groups of same-aged children to acquire mathematical concepts

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and skills through integrated play. Individual preschools are responsible for designing mathematical (and other) activities. The authors believe that observing a mathematical group activity in a Japanese preschool provides an opportunity to analyze the mathematical roles of finger gestures.

THEORETICAL FRAMEWORKS AND RESEARCH QUESTIONS

In the process of illustrating his theory, Radford (2016b) proposed the idea of joint labor—where students and teachers work together to create common work—as a key theoretical construct. The theory is built on a Vygotskian view of activities, the aim of which are

> the dialectic creation of reflexive and ethical subjects who critically position themselves in historically and culturally constituted mathematical practices and ponder and deliberate on new possibilities of action and thinking. (Radford, 2016a, p. 4)

Radford (2016a, 2016b) calls such specific activities joint labor, arguing that subjectification and objectification are two sides of the same coin. These processes occur simultaneously during an activity:

> Learning can be theorized as those processes through which students gradually become acquainted with historically constituted cultural meanings and forms of reasoning and action. Those processes are termed processes of objectification (Radford, 2015, p. 551, italics in the original)

> [O]bjectification is more than the connection of the two classical epistemological poles, subject and object: it is in fact a dialectical process—that is, a transformative and creative process between these two poles that mutually affect each other […] Subjectification is the making of the subject, the creation of a particular (and unique) subjectivity that is made possible by the activity in which objectification takes place. […] [L]earning is both a process of knowing and a process of becoming (Radford, 2015, p. 553)

The concept of joint labor, thus, reconceptualizes teaching. A mathematics teacher both objectifies a new aspect of the mathematical concept to be taught and subjectifies herself as two sides of the product of a collaborative activity with her students. Radford (2016a) views:

> [T]eaching and learning not as two separate activities but as a single and same activity: one where teachers and the students, although without doing the same things, engage together, intellectually and emotionally, toward the production of a common work. Common work is the sensuous appearance of knowledge (e.g., the sensuous appearance of a covariational algebraic or statistical way of thinking through collective problem posing and solving and discussion and debate in the classroom). […] The joint labor-bounded encounters with historically constituted mathematical knowledge materialized in the classroom common work are termed processes of objectification. (p. 5, italics in the original)

Based on the abovementioned theoretical frameworks, our research questions are as follows: 1) How does the process of subjectification and objectification proceed in a mathematical activity at a Japanese preschool? and 2) How do mathematical roles of finger gestures for preschool children change in the process?

METHOD

Research Design

As mentioned, Japanese preschools design and implement the annual plan for activities on an individual school basis. The present authors have an interest in the development of children's mathematical abilities during activities implemented as a part of the curriculum. The first author of the current paper has collaborated with a Japanese private preschool on the development of a mathematics curriculum. That school participated in the study.

From the perspective of joint labor, we focus on an activity featuring mathematical quizzes where students and teachers quiz each other regarding the number of bananas belonging to a monkey. The episode of activity presented in the paper is short-term; longitudinal research on joint labor is recommended for documenting processes of objectification and subjectification (cf. Radford, 2015, 2011). Instead of the longitudinal track of studying children's mathematical development, we adopted a microgenetic approach to capture the processes of developmental changes themselves in short-term episodes rather than only milestones, or snapshots of development (Lavelli, Pantoja, Hsu, Messinger, & Fogel, 2008). Indeed, even Radford reported a set of short-term episodes as parts of the historical processes of objectification and subjectification (e.g., Radford, in press, 2016b, 2011). Accordingly, we recorded the entire session and then selected a salient segment to analyze in terms of joint labor. We did not follow the remaining procedures proposed by Radford (2015) because our focus on joint labor is a relatively new application of his theory, and its means of identification have not yet explicitly emerged in his methodological formulations (2015). Instead, our analysis was inspired by the steps used in the microgenetic approach (Lavelli et al., 2008): (1) roughly identify stable and changing components of the relationship between children and teacher through repeatedly watching a clip; (2) transcribe the clip chronologically; (3) divide the transcription into several frames; and (4) create a storyline synthesizing the frames to explain the stable and changing components.

Procedure (4) for creating the storyline is further divided into four steps: (4.1) identify joint labor based on stable and changing components of the relationship between children and teacher; (4.2) interpret the algebraic knowledge which emerges through the joint labor; (4.3) interpret how it emerges, i.e., how it is objectified; and (4.4) interpret how the children subjectify themselves.

RESULT

Children's Activity

In the implemented activity, after the children watched a video clip on wild animals, the teacher introduced an activity about monkeys and their lives. When the children and teacher

sang a song about monkeys, she introduced questions about 1-digit addition and subtraction. Children were encouraged to use their fingers, with each finger representing one of the monkey's bananas. As she quizzed the children regarding the number of bananas, they calculated their answers by watching and counting the teacher's presenting fingers. After that, the children indicated that they wished to share their own quizzes by raising their hands. The teacher selected students one by one, and each in turn came to the front of the class and took on the teacher's role. Their questions followed the sentence format for verbal expressions provided by the teacher, a common pedagogy at the school. Children provided simple addition and subtraction problems, including 10 - 5, 4 - 1, 10 - 8, 10 - 5, 10 + 2, and 11-3, to their seated peers, who listened and answered the quizzes together by counting the presenting student's fingers. Student presentations were followed by additional presentations from the teacher, followed by presentations from the remaining students who quizzed their peers on 10 - 9, 10 - 7, 5 + 4, and 9 + 1.

The focal scene comprised the penultimate question asked by a student. Following the third procedure for microanalysis, the transcription was divided into six frames. All the conversations were in Japanese and were translated into English by the authors. All children's names are pseudonyms.

Frame 1 features a male child's question.

182 Yu: (Singing a song.) Quiz, quiz
183 SS&T: What is the quiz?
184 Yu: (Singing.) Quiz of answering the number of bananas.
185 SS&T What is the question?
186 Yu: Here are 12 bananas. A monkey put 5 more bananas. How many bananas are there altogether?

After Yu's question, the teacher wryly smiled, likely due to the large size of the number, considering the ages of the children, but decided to continue the game.

187 T: It seems more difficult than before. Okay, okay. Let us try.
188 SS: (Raising their hands.) Yes, me.

Frame 2 shows the teacher's confirmation of the content of the question.

189 T: How many bananas were there in the beginning?
190 Saki: 12.
191 T: 12. And how many bananas were added?

Frame 3 shows a conflict between children.

192 Yu: (Pointing to a child, saying her name.) Hiroko.
193 Hiroko: 17.
194 Yu: Wrong.

Though Hiroko correctly and quickly answered, Yu did not seem to correctly understand what she said. After denying her answer immediately once he put a troubled look on his face.

Frame 4 shows the conversations between Yu and teacher to reconfirm the question.

195 T: Let us think together.

196 Yu: Wrong.
197 T: Wasn't it right? What was the answer?
198 Yu: 16.
199 T: 16. Well, let's think together. It became more challenging than before.
200 Yu: There were 12 bananas and the monkey added 5 more bananas, and then…

Frame 5 shows the start of a collaborative discussion using finger gestures.

201 T: Well, in the beginning, the monkey had 10 and 2 bananas. (Showing her 10 fingers and using 2 of Yu's right fingers.)
202 T: So, there are 12 and it added 5 more… (Showing 10 with her hands and letting Yu show 7 more with his hands.)
203 Konoha: There are 16 bananas.
204 T: 16 bananas?
205 Yu: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17.
206 T: Thus? Right! Wonderful! (Clapping) It became difficult gradually.

The teacher demonstrated the use of finger gestures, and the children followed her lead, actively counting using finger gestures.

Frame 6 shows Hiroko's reasoning about the solution to 12 + 5. Immediately after recognizing that her friends obtained the same answer she had, 17, by using finger gestures, she saw the connection between 12+5 and 2 + 5 and argued the point.

207 Hiroko: Well, 2 + 5 = 7. (Showing her 2 and 5 fingers together)
208 T: Wow, well, you counted! I see, so let us do the final one? Please.

Created Storyline

The activity presented constitutes joint labor between children and teacher. We regarded it as joint because its production was considered historically contingent. The quiz was given by Yu, a child, not by the teacher (Frame 1). Following her song format he invented a quiz by selecting the numbers 12 and 5 by himself. Although his quiz was relatively difficult for most children besides Hiroko, they finally obtained the answer '17' with the assistance of the teacher (Frame 5). The role of the teacher was to provide neither the quiz nor the answer. She only provided the format of the activity and demonstrated the use of finger gestures. That is, her role of supporting the children did not change when they presented quizzes. Instead, the children were free to decide (Frame 5) whether to count on their fingers as the teacher had modeled. The children's focuses actively changed following their interactions with the teacher. Their joint labor was visible in that particular scene.

During the joint labor, three kinds of algebraic thinking emerged as common work. First, Yu proposed new numbers: 12 and 5. The teacher's smile indicated that she did not expect her children to use a number as large as 12. However, contrary to her expectations, Yu realized that he could use larger numbers for quizzes. In the beginning, the teacher controlled the rules, but ultimately such role was delegated to the children, which might have prompted Yu to further develop the scope of the questions. In this process, the children

objectified the new numbers as part of the quiz and gradually subjectified themselves as new quiz producers.

Second, the children used finger gestures to determine the number of bananas. They did so under the teacher's facilitation. For example, since the number 17 was too large for the children to quickly count, Konoha counted her fingers in error (Frame 5). The finger expressions of the number, however, spatially maintained the initial assumption of the quiz that there were twelve and five bananas and mediated the children's repeated and careful counting. Therefore, adding and counting, kinds of algebraic thinking, are re-embodied and re-mediated by the artifactual use of the fingers by the teacher. The children re-objectified finger gestures as tools for solving the conflict over the solution and re-subjectified themselves as the finger gesture users in solving the quizzes.

Third, Hiroko realized that 12 + 5 was separable into 10 and 2 + 5. Since she immediately answered the quiz, she might have already known how to calculate this way before the joint activity. Only the teacher recognized what Hiroko asserted; the other children, including Yu, did not respond to her. Her separating strategy was difficult for the others, who depended on the finger gestures. She objectified the separating strategy as a tool for solving the quizzes, but her subjectification could not be determined from this observation. When she uses the strategy again in the future, her subjectification might be gradually determined, depending on the responses from members of her community.

DISCUSSION AND CONCLUSION

Our observation of the children's reuse of finger gestures shows that spatial and numerical structures are linked in accord with Radford's (2011) claim that algebraic thinking is by nature embodied and mediated by artifacts. On the other hand, the children needed the teacher's suggestion to finger gestures. Although they repeatedly used finger gestures before the focal scene, they did not themselves propose to use them to resolve Hiroko's and Yu's conflicting solutions. This fact does not completely fit into Radford's (2008) theoretical assumption that humans on their own preserve artifacts' meanings. The children appeared to obtain help from the teacher to reconstruct the meaning of fingers as a tool for solving quizzes rather than demonstrating the preserved meaning in practice. Although the ability to preserve the meaning of artifacts might be built into human beings by nature, we may need to be taught to demonstrate such ability.

However, that the children did not use finger gestures should not be construed negatively. Instead of focusing on the intermediate process of the finger gestures, they seemed to focus on input and output. This could be an origin of flexible thinking, also called proceptual thinking (Gray & Tall, 1994), which is based on a focus on the relationship between input and output. It is natural and mathematically appropriate for finger gestures to lose their artifactual meaning for children as they master adding two numbers mentally.

We agree with Radford's (in press) argument that social rules and mathematical content in classrooms are part of the fabric of children's subjectivities. Our interpretation and analysis corroborate this. We draw one possibly important implication: the role of the

knowledgeable other, in this case the teacher, in solving conflicts between learners' idiosyncratic rationalities. The observed children showed their own valuable abilities: Yu's ability to generate a new quiz, Hiroko's strategy for addition without counting, and other children's focus on the input-output relationship. However, these are still potential abilities and are not always performed in appropriate situations. Teacher intervention may potentially show them when to perform their abilities. We argue, therefore, that the traditional constructivist focus on learners' own idiosyncratic rationality (Confrey, 1991) can be more widely investigated from Radford's theoretical perspective.

Let us finally answer our two questions. First, in accordance with Radford's theory, the subjectification and objectification proceeded in the scene of preschoolers' and teacher's conversations regarding addition; joint labor in a classroom activity offers a valuable opportunity to investigate these processes. Second, through teacher mediation, the role of finger gestures was reconstructed to solve a conflict over a mathematical problem. In addition to Radford's assumptions about the ability of human beings to preserve the meanings of artifacts, we suggest that for young children, learning may be part of that process. As our methodology is, at this stage, suggested, our interpretations will be refined each time we obtain new empirical data.

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