ACTIVITY-BASED CLASS: DILEMMA AND COMPROMISE

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Experiencing mathematics through activity rather than rote memory and repeated practice has been emphasized. Textbooks introduce a variety of activities that help students understand mathematical knowledge. Teachers should understand the content of, and the idea behind, activities first and then make them play out vividly in the classroom. However, activities often distract students’ attention and divert the focus of the classes away from its original purposes. This paper aims to identify the dilemma and compromise of activity-based mathematics classes by examining the reflective review of a teacher on his classes about geometric figure movement and the discussion by three incumbent teachers on the classes.

INTRODUCTION

Korean mathematics curriculum puts an emphasis on activity-based mathematics classes (Ministry of Education, 1998). This is in line with research results claiming that activities, especially those based on manipulative material and technology facilitate mathematical learning (Thompson, 1994; Edwards, 1998). As Ball pointed out (1992), however, students don’t always go beyond activities themselves and learn what their teachers intend them to learn. Cobb et al. (1992) argue that when teachers and students use manipulative material, their communication tend to focus on interpretation of the newly introduced material, not mathematical knowledge. In activity-based mathematics classes, it is not always possible to gain knowledge from activities and there is a constant danger of interest shift to activities themselves in a significant way. Of course, proper communication on concrete materials may give students an opportunity to discover mathematics on their own.

Dowling (1995) also argues that mathematics education as it is widely practiced is a mythologizing activity in the sense that it regards activities themselves as instances of, or representable by, mathematics. It is necessary to determine whether activities in class exactly represent mathematics or how distant they are from mathematics. The belief that activities alone will guide students towards mathematical knowledge is no longer sustainable.

Activity-based mathematics class has been emphasized and implemented in Korea since the 1990s. Now, it is time to analyse a variety of activity-based classes and find a new direction. This research aims to analyse classes on geometric figure movement by focusing on a teacher’s analysis of activities in textbook, use of the activities in classes and students’ perspectives. It also takes a look at the discussion by incumbent teachers about the classes on geometric figure movement and the teacher’s reflective review. To achieve these objectives, this research was conducted focusing on the following two questions:
What kind of use and understanding of textbook activities do teachers develop?
What kind of difficulties or dilemmas do teachers find in mathematics classes while using activities to teach mathematical knowledge and what compromise do they reach?

THEORETICAL FRAMEWORK

The content of the teacher’s analysis on textbook activities will be re-analysed in comparison with research results by Kang & Kilpatrick (1992), Dowling (2001) and Kulm et al. (2000). This research will identify how the teacher recognizes the changed nature of knowledge with the introduction of activities (Kang & Kilpatrick, 1992); how much he understands the goals and characteristics of activities in the textbook, and directness and indirectness of experience (Kulm et al., 2000); and whether he considers different interpretive frameworks between him and his students (Dowling, 2001).

The didactic situation concept introduced by Brousseau (1997) consists of the learners, the teacher, the mathematical content and the culture of classes, as well as the social and institutional forces acting upon that situation, including government directives in the national curricula documents, inspection and testing regimes, parental and community pressures and so on. He also introduced didactic contract which is about a kind of pressure or tension existing between teacher and learners. It is very important to decide if teachers and students abide by this contract while teaching and learning. If a teacher doesn’t offer learners opportunities to explore mathematical knowledge, then he or she violates the didactic contract and that situation is not didactically appropriate (Brousseau, 1997). This research examines what kinds of didactic situation and didactic contract do Korean elementary mathematics teachers seem to have. Use of activities in classes and students’ perspectives will be analysed by using didactic situation concept introduced by Brousseau (1997); the didactic pole and the cognitive pole coined by Bartolini Bussi et al. (2005); the didactic transposition by Chevallard (1985).

METHOD

To find out how a teacher understand textbook activities and use in his or her classes, this research was performed following the research method that intentionally conducts the sampling of proper cases, observes and makes an in-depth analysis (Strauss & Corbin, 1990). K, the teacher who participated in this research and provided materials and issues on activity-based mathematics classes, has been teaching for 12 years but is not confident in activity-based mathematics classes. He says he is increasingly less confident as greater emphasis has been put on activities in curricula and textbooks. According to his fellow teachers, however, K always spends significant amount of time and energy in preparing for his classes and materials for activities. He wanted to know whether he has the right understanding of activity-based mathematics classes and what a typical activity-based math classes that most teachers are able to implement would look like. The three incumbent teachers, C, L and P, discussed K’s classes from the viewpoint of potential and limitation of activity-based classes and tacit
compromise among teachers. They have taught for 3, 7 and 15 years respectively, covered chapters taught by K and are very active in reviewing research results at a variety of teachers’ study groups.

This research focuses on six hours of classes on geometric figure movement. The classes, interviews with K before and after the classes and a discussion by C, L and P were all videotaped and analysed. In addition, curriculum guidelines on geometric figure movement, activity sheets prepared for classes; activity sheets filled in and submitted by students and questionnaires given to the students were collected.

RESULTS AND DISCUSSION

K decided that he needed to teach his students about parallel transposition, symmetric transposition and rotational displacement without using coordinate in a way that is easily understood by elementary school kids by the appropriate didactic transposition (Chevallard, 1985). He analysed the textbook, the teacher’s guide, and the curriculum documents to prepare lessons.

K’s Analysis of Textbook and Reconstruction

K determined he would use activities because he had to teach third graders parallel transposition, symmetric transposition and rotational displacement without the use of coordinate. He recognized that a certain change was attempted in textbook to make mathematical knowledge easily understandable by elementary school students as analysed by Kang & Kilpatrick (1992).

For example, a current textbook presents an activity of turning the desk as illustrated in Figure 1. K pointed out the activity doesn’t represent rotational displacement in the mathematical sense. He also expressed his concern over the gap between textbook activities and mathematical knowledge they are supposed to represent cases of parallel transposition and symmetric transposition. K said none of the 11 textbook activities faithfully serves the original purpose and that he was worried about meta-cognitive shift as pointed by Kang & Kilpatrick (1992).

K decided it was crucial to teach the basic concept of moving geometric figures through activities although he was aware of the gap between textbook activities and mathematical knowledge. He thought moving geometric figures directly and checking the result was very important in classes. K’s position could be interpreted as supporting textbooks that emphasize direct experience - one of the criteria suggested by Kulm et al (2000). He didn’t regard learning from illustration or demonstration by the teacher as activity-based mathematics education. This implies that he knows the characteristics of the knowledge to be taught, in particular the dependence between the mathematical objects which must be taken into account in the creation of the coherence in the content
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to be taught and recognizes some constraints in didactic transposition of the knowledge in geometric figure movement (Brousseau, 1997; Laborde, 1989; Chevallard, 1985).

K often mentioned different interpretative frameworks between him and his students (Dowling, 2001). The current textbook encourages students to check the result of geometric figure movement by asking, “Has the geometric figure changed?” and this approach is perfectly reasonable from K’s perspective. However, K suspected his students would think that geometric figure movement and change in geometric figure are closely related and that the geometric figure has changed after movement, rather than remained the same.

K pointed out that while it is good for textbooks to present activities, they fail to explain why students should be engaged in the activities. This is why he decided to mention the reasons for studying geometric figure movement at the beginning of his classes and to illustrate how geometric figure movement is used in real life with a variety of examples. These examples included photos of cultural properties and buildings, and design-related materials on the Web.

Dilemma from simplified activities

At the beginning of his first class, K showed his students different patterns collected from the Web, especially those depicting the same repeated geometric figure and asked “what they feel and whether they recognize order in beauty.” He presented Korean traditional designs in tile roof, the dancheong patterns on the edge of the eaves, the taegeuk pattern and so on (See Figure 2), and pointed out that the “beauty of orderly patterns” has long been the focus of attention. K also asked his students, “How do you think the original creators came up with the designs? What might they have done before completing the designs? For example, they might have started by drawing something first on a piece of paper.”

![Figure 2: Pictures shown on the screen (Dancheong and Taegeuk)](image)

Then, K asked his students to think about the learning points of the chapter on geometric figure movement and the meaning of the word movement, and told them about how the knowledge in the chapter is applied such as in making wall papers and floor materials and designing scarfs and clothes. After that, he projected examples of geometric figure movement on a screen. With the screen showing activities in textbook, K had his pupils check whether the shape of the geometric figure on the screen changes when it is moved in four different directions: upward, downward, left and right. K then handed out a piece of paper with a geometric figure drawn on it to each of his students and asked them to move the geometric figure in four different directions and determine...
whether the shape of the geometric figure changes. This was when an interesting debate took place between two kids at the back of the classroom.

Student 1: (She moves the geometric figure diagonally.) This is also geometric figure movement, right?

Student 2: No, you can only move it upward, downward, left and right.

Student 1: No, I don’t think so. It is just that the textbook shows only four ways of moving the geometric figure. Let’s ask him. (In a loud voice) Mr. K, this is also geometric figure movement, isn’t it?

K: Huh? Did you move it to the right?

Student 1: No, to the upper right.

K: To the right?

Student 1: Not just to the right. I move it to the right and also upward.

K: (He approaches to Student 1.) What do you mean by that? (He looks the student’s action.) Yes, that is also geometric figure movement in reality…. (After a pause), but you need to choose between right and upward in this mathematics class. (After a pause) OK, has the geometric figure changed or not after being moved?

Student: It hasn’t.

K: Then it’s OK. It’s alright as long as you understand that the shape of the geometric figure has not changed after movement.

The current textbook does not clearly explain what movement means in the mathematical sense. It only focuses on geometric figures not changing after being moved upward, downward, left and right and doesn’t specify how much and in what direction the geometric figures should be moved. It is a simplified form of knowledge in geometric figure movement so that teachers hardly find appropriate further explanation to add.

K didn’t seem to control the situation in the above dialogue and almost gave up teaching about the reason why the word movement is interpreted in that way, which can be interpreted as the situation closes to a-didactical one in the sense that K transmitted the responsibility of handling knowledge to the learners (Brousseau, 1997). C, one of the discussants, recalled a day when he taught in a second grade class while analysing this episode. When he asked, “What has changed after we placed a geometric figure we drew on the windowpane and open the window?” a student answered, “It is cooler because of the breeze coming in.” This episode shows the students didn’t understand the intention of the question and the activity. In K’s classes, the definition of the geometric figure movement activity was changed by the students’ knowledge and experiences regarding the linguistic meaning of movement (Bartolini Bussi et al., 2005).

Dilemma from the distance between mathematics and activities

K decided it was important to draw the result of geometric figure movement on section paper. The textbook has students transfer a geometric figure to transparent paper, place
the transparent paper on section paper and transfer the geometric figure again by plotting points. K thought this process of transfer to transparent paper and re-transfer to section paper would have no meaning to his students since it doesn’t give any insights into the underlying mathematics. So he changed the activity to drawing the moved geometric figure without transparent paper while stressing the concept of basis line. At first, K explained by using transparent paper but introduced the basis line concept.

K: What do we need to draw a moved geometric figure?
Students: A triangle.

K: No, I mean what we need to know before movement. A basis line, right? (He shows the basis line on the screen.) Then the only thing we need to consider is the number of squares located between the basis line and the figure. How do we do it? (Projecting the picture on the screen) Take a look at this geometric figure. As I mentioned, this line serves as the basis. Look at the line. How do we draw the moved geometric figure here? Think of it as being reflected in the mirror. We should leave one column blank on each side and draw the geometric figure by using one, two, three rows to make it the same as the one on the opposite side. Do you see how important a basis is now?

K tried to make his students understand axis of symmetry to a certain degree by introducing the basis concept that is never mentioned in the textbook. When he explained about symmetric transposition, K only turned around section paper in the air. However, he deliberately used material with a basis marked on it to show his students how to describe the result of geometric figure movement. This is a didactic device for using textbook activity as the first artifact and utilizing language and picture to move toward the second artefact (Bartolini Bussi et al., 2005).

K emphasized on the procedural knowledge of describing the result of textbook activities mathematically, whereas textbook focuses on the procedural knowledge of describing the activities in terms of the use of concrete materials including transparent paper. Thus his students participated in the different activities under K’s direction. In the discussion on K’s classes, L and P said that K was, in a way, teaching a fixed scope of mathematical knowledge when using activities. This, they concluded, prevented a variety of approaches from taking place while making his classes stable and poised despite the use of activities.

**Dilemma from visual representation of activity**

The chapter on rotational displacement in the textbook did not specify rotation angle like 90° or 180°. Instead, it depicted the degree of the rotation on a round-shaped figure. K explained in detail how to describe this depiction.

K: Do you see the clock-like thing in the middle? What time is it? I mean, it is not a real clock, but it looks like 3 o’clock, right? To 3 o’clock, until it reaches 3 o’clock. No, not 3 o’clock, but the angle that represents 3 o’clock. You know what a right angle is, don’t you? Three o’clock is a right angle, right?

Students: Yes.
K: As much as the right angle to the right. That is… (demonstrating a rotation) to move, no, to rotate up to this point until it forms a right angle. How many times has a rotation been done to the right? Let’s call it a half of the half rotation from now on.

K believes in socio-cultural perspective in mathematics learning (Cobb et al., 1992). However according to his analysis, the textbook didn’t offer him suitable tools to communicate with students on how much figure is rotated. When he decided that the visual depiction in the textbook was not enough for proper communication, K developed a linguistic depiction such as a half of the half and taught it to his students. They practiced and internalized the expressions presented by K and put them together to form mathematical knowledge.

In K’s classes, the students thought and learned based not on visual depiction in the textbook, but on additional expressions that K created. There were few instances where a student devised a new expression or depended on his/her own interpretation during activities. C, a discussant, argued K deprived his students of an opportunity to express and internalize their own thought processes while P said that the activities were implemented in a significant way because K skillfully distinguished different and confusing concepts, which can cause so called Topaz Effect (Brousseau, 1997). Interviews with the students found they clearly remembered detailed guidelines that K presented and saw the guidelines as important. This gave an impression that the activities were regarded somewhat as an established piece of knowledge.

CONCLUSION

Activities implemented by K were not identical to those in the textbook by his own didactic transposition (Chevallard, 1985). After his classes was over, K said, “I agree with the idea behind activity-based mathematics classes but believe we should guard against a situation where students engage in activities without much thought. If detailed procedures are not presented, students will be lost in activities without gaining mathematical knowledge. The teachers who participated in the discussion also share a view that “focusing on the activities themselves weakens attainment of mathematical knowledge and vice versa.” This is the dilemma of activity-based mathematics classes recognised by K, which represents the gap between the knowledge to be taught and the knowledge taught (Chevallard, 1985).

As K did, many Korean mathematics teachers reconstruct textbook activities into different detailed activities and ensure that the approaches taken by students are not overly varied. C described this as an indispensable approach because they often find dilemmas in their activity-based classes. P expressed this as a compromise shared among teachers. K argued that it is necessary for teachers to discuss on the dilemmas and the compromise by themselves since teachers have a very different view of the uses and purposes of activity. Activities are essential in teaching mathematics, but their effective use is not always straightforward and they can work against the didactic intent. Identifying dilemmas and compromise in activity-based classes recognised by teachers can be a significant way of professional development in teacher education and
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bridging the gap between the theoretical and the empirical approaches in mathematics education.

References


