EVALUATION AND RECONSTRUCTION OF MATHEMATICS TEXTBOOKS BY PROSPECTIVE TEACHERS

Kyung Hwa Lee
Korea National University of Education

This paper provides an analysis of prospective teachers’ evaluation and reconstruction of mathematics textbooks. Thirty-four prospective teachers participated in the three-hour lecture and discussion for 15 weeks. Data consisted of final reports written by the prospective teachers, interviews and lecture observations. The purpose of this study is to grasp the process in which prospective teachers, based on the study of Kulm et al. (2000) and of Shield (2005) on the evaluation of textbooks and the researches related to analysis by Kang & Kilpatrick (1992), Dowling (2001), and Herbst (1997), establish their own evaluation and analysis method of textbooks. In addition, this research intends to identify the process in which they reconstruct textbooks based on the results of their analysis.

INTRODUCTION

Ball (2003) insists that we need better insight into the ways that materials and institutional contexts can either assist or impede teachers’ efforts to use mathematical knowledge as they teach. She also suggests to consider questions such as how teachers’ guides can be crafted to provide opportunities for teachers to learn mathematics, how they can be designed such that teachers understand the mathematical purposes pertinent to an instructional goal, how those guides can be designed to help teachers use their mathematical knowledge as they prepare lessons, make sense of students’ mistakes, and assess students’ contributions in a class, etc. Kulm et al. (2000) presented a method to evaluate mathematics textbooks based on the detailed standards of the statement of objectives, suggestion and development of contents elements and the evaluation processes, etc., and the data earned from the comparison and evaluation of various textbooks. Shield (2005), starting from the achievement of Kulm et al. (2000), offered the process of pertinently transforming specific contents elements in a curriculum into the knowledge in a textbook and, based on which, the way to evaluate textbooks. In a situation where various kinds of mathematics textbooks are being published, it is a part of the specialty of a mathematics teacher to decide on which standards he would apply in choosing and using a textbook.

Kang & Kilpatrick (1992) analysed didactic transposition of mathematics textbooks and identified potential extremes in the didactic phenomena. Kang(1990) elaborated the process of the construction of school mathematics as the body of knowledge declared by mathematics educators. Dowling (2001) analysed mathematics textbooks in a sociological perspective and presented an interpretative framework that exist between teachers and students, and between students. Herbst (1997), through the analysis of number-line metaphor found in mathematics textbooks, showed the
mathematical discourse of a textbook as an environment where one can find mathematical discourse that is subject to a regime, possibly different from official the discourse of mathematicians. The ability to analyse a textbook in diverse perspectives is another part of the specialty of a mathematics teacher.

The purpose of this research is to grasp the process in which prospective teachers, based on the study of Kulm et al. (2000) and of Shield (2005) on the evaluation of textbooks and the researches related to analysis by Kang & Kilpatrick (1992), Dowling (2001), and Herbst (1997), establish their own evaluation and analysis method of textbooks. In addition, this research intends to identify the process in which they reconstruct textbooks based on the results of their analysis.

PROCEDURES

Thirty-four prospective teachers participated in the three-hour lecture and discussion for 15 weeks in the fall of 2005. In the first 10 weeks, they confirmed the contents of the studies of Kulm et al. (2000), Shield (2005), Kang & Kilpatrick (1992), Dowling (2001), and Herbst (1997) through lecture and discussion of illustrated materials. And for five weeks thereafter, they tried the evaluation and analysis of Korean textbook A, Korean textbook B and teacher’s guides for the 8th grade students. A total of 10 teams, which consisted of 3 or 4 people, evaluated, analysed and announced the results thereof, and then were asked to criticize the attempts of each team and draw significant conclusions. Discussion among team members during the preparation of the announcement was recommended; in most cases, they prepared the arranged version of the contents discussed, sent it to the e-mail account of the researcher to receive his criticism three or four times. In a website, the announced materials, related theses, contents of discussion of each team were uploaded to be shared, and free discussion on the website was also made possible. After 15 weeks, they finally prepared the report on the results of their evaluation and analysis and the plan for their own reconstructed version, and submitted them. Three prospective teachers of P1, P2 and P3 participated in the interview, which was held based on their final reports. The announcements, discussions of prospective teachers during the 5 weeks and the interviews with the three prospective teachers were recorded and analysed. The researcher looked at a group of prospective teachers interacting, connecting ideas, and building their understanding together as Droujkova et al. (2005) properly addressed.

In this research, the evaluation of mathematics textbooks was made, applying the seven categories suggested by Kulm et al. (2000), which are ‘Identifying Sense of Purpose,’ ‘Building on Student Ideas about Mathematics,’ ‘Engaging Students in Mathematics,’ ‘Developing Mathematical Ideas,’ ‘Promoting Student Thinking about Mathematics,’ ‘Assessing Student Progress in Mathematics’ and ‘Enhancing the Mathematics Learning Environment.’ Utilizing all the 24 evaluation standards under the 7 categories, High, Medium and Low were given the scores of 3, 2, and 1, respectively, and the average was produced. Analysis of textbooks was made by team applying the selected method after consulting the contents of the researches conducted by Shield (2005), Kang & Kilpatrick (1992), Dowling (2001) and Herbst
(1997). All the prospective teachers were asked to try reconstructing the textbooks based on the results of evaluation and analysis and submit it.

RESULTS AND DISCUSSION

The average scores of evaluation results by category of the two textbooks on which prospective teachers submitted the report are as follows:

<table>
<thead>
<tr>
<th>Category</th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identifying a Sense of Purpose</td>
<td>1.6</td>
<td>1.7</td>
</tr>
<tr>
<td>Building on Student Ideas about Mathematics</td>
<td>1.0</td>
<td>1.1</td>
</tr>
<tr>
<td>Engaging Students in Mathematics</td>
<td>1.1</td>
<td>1.3</td>
</tr>
<tr>
<td>Developing Mathematical Ideas</td>
<td>2.4</td>
<td>2.3</td>
</tr>
<tr>
<td>Promoting Student Thinking about Mathematics</td>
<td>2.0</td>
<td>1.8</td>
</tr>
<tr>
<td>Assessing Student Progress in Mathematics</td>
<td>2.3</td>
<td>2.2</td>
</tr>
<tr>
<td>Enhancing the Mathematics Learning Environment</td>
<td>1.6</td>
<td>1.4</td>
</tr>
</tbody>
</table>

Table 1: Evaluation of mathematics textbooks by the prospective teachers

As shown in Table 1, the prospective teachers gave similar ratings to the two textbooks and they particularly gave low ratings on the categories of ‘Building on Student Ideas about Mathematics,’ ‘Engaging Students in Mathematics’ and ‘Enhancing the Mathematics Learning Environment’ (see shaded parts in Table 1). As to ‘Developing Mathematical Ideas’ and ‘Assessing Student Progress in Mathematics,’ both the two textbooks were given relatively high ratings.

Building on Student Ideas about Mathematics

According to Kulm et al. (2000), this category consists of the evaluation standards of ‘Specifying Prerequisite Knowledge,’ ‘Alerting Teacher to Student Ideas,’ ‘Assisting Teacher in Identifying Ideas’ and ‘Addressing Misconceptions.’ The reports of prospective teachers showed that the two textbooks explicitly deal with what prerequisite knowledge of students is required. However, the textbooks, according to the report of the prospective teachers, made almost no attempt to identify the misconceptions students might have, or a certain mathematical knowledge or functions they are presumed to have developed based on common knowledge. Particularly, to the question of ‘Does the material include suggestions for teachers to find out what their students think about familiar situations related to a benchmark before the mathematical ideas are introduced?’ both the two textbooks were judged not to provide good materials to teachers.

The prospective teachers’ interpretation of this was, since traditional approach has been aiming at an “efficient and correct method,” a diverse, intuitive or experimental approach has rarely been adopted. This seems to be a problem common to most of Asian textbooks where compact-style textbooks are generally pursued. On the other hand, the prospective teachers agonized over to what extent a textbook should reflect the ideas and functions students in general might have. Also, the argument over whether those ideas are as numerous as the number of the students was continued. Eventually, the argument was settled after one of the ten teams conducted a research
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on misconceptions, with the students attending the middle school attached to the college of the prospective teachers as subjects, classified the types of misconceptions and announced them. And they reached the conclusion that since the misconceptions students might have had already been studied, if a research was conducted with some students using a modified examination paper, results that can be classified into types to an extent can be obtained, and this need to be reflected in textbooks whenever necessary.

**Engaging Students in Mathematics**

The reports of prospective teachers showed that the two textbooks explicitly deal with what prerequisite knowledge of students is required. However, the textbooks, according to the report of the prospective teachers, made almost no attempt to identify the misconceptions students might have, or a certain mathematical knowledge or functions they are presumed to have developed based on common knowledge. Particularly, to the question of ‘Does the material include suggestions for teachers to find out what their students think about familiar situations related to a benchmark before the mathematical ideas are introduced?’, both the two textbooks were judged not to provide good materials to teachers.

As sub-standards of this category, Kulm et al. (2000) suggested “Providing Variety of Contexts” and “Providing Firsthand Experiences.” The prospective teachers judged the domestic textbooks fail to offer diverse problematic situations. For example, in the unit of probability, most of the situations in problems were composed of coins, dice, card, etc.; and those cases where students were given the opportunity to collect materials through experiments were judged to be rare. Also, teaching an outer center or inner center of triangle unduly relied on deductive explanation; and seemed to be lacking the attempts to make students feel that mathematics is related to the realities of life.

The prospective teachers displayed the highest interest in providing diverse problematic conditions, particularly firsthand experiences; and from this high interest, the major viewpoint in reconstructing textbooks was drawn. For example, they thought coins or dices are not appropriate as an introduction to experimental probability and tried reconstruction using a game of Yut, a local folk game, as the problematic situation. A yut is formed with a round face and a flat face, and unlike a coin, the two faces are not symmetrical, which means they do not have the same possibility. Therefore, their theory goes since students can compare the numerical difference in possibility of the two faces only after going through sufficient number of experiments, using Yut enables them to start with the meaning of experimental probability. In the case of the inner center and outer center of a triangle, they suggested imposing the problematic situation of restoring cultural artefacts as a starting point. They argued that to restore the original form of an artefact that is broken, the effort to first find out the outer center by drawing a triangle has to be made, and accordingly, through the effort, the students can experience how mathematics can be applied practically.
Enhancing the Mathematics Learning Environment

The prospective teachers insisted that a teacher’s guide has to offer a variety of information on the backgrounds of the contents to be taught, and judged the current teacher’s guides fall far short in this aspect. They thought though the guide contains knowledge about the history of mathematics and the knowledge of various fields other than mathematics, the level of knowledge offered was no better than superficial.

According to them, a positive change has been detected in that they accommodate the diverse opinions of students and take them as subjects of discussion, not acknowledging only those that are suggested in textbooks as truths. However, they argued this need to be pursued more positively. Some of the prospective teachers pointed out that textbooks are being written in such a way that is more favourable to male students: in many cases, the problematic situations offered in the textbooks are the ones related to the fields of sports or science, which may make the problem more difficult for female students to understand. Also, some participants noted that the explanations given in textbooks are overly compressed and make learning more difficult for slower students.

Case of P1

P1, a prospective teacher, used a notion related to extreme teaching phenomenon that was presented in Kang & Kilpatrick (1992) as a major tool in analysing textbooks. She maintained that the series of contents in the textbooks that express a repeating decimal as a fraction after indicating a rational number as a decimal and classifying a decimal into a finite decimal, an infinite decimal and a repeating decimal, is treated in an unstable manner, which leads teachers to reach the phenomenon of extreme teaching. The following is a part of conversation between the researcher and P1:

1 R: Do you think the textbook caused the phenomenon of extreme teaching?
2 P1: Yes. If the process of converting a repeating decimal into fraction was clearly expressed in mathematical viewpoint, it does not matter. But the demonstration suggested in the textbooks applied the measuring system for the finite to the infinite without providing any justification.
3 R: How is that related to the phenomenon of extreme teaching?
4 P1: Because the teacher ends up without underlining the principle or the meaning of demonstration emphasizing the formula which alters it to a fraction.

The prospective teacher P1 also explained why the current textbooks make such an approach: there is no alternative in order to introduce an irrational number to the middle school students who are not aware of the notion of utmost limits. In the case like this where the mathematical exactness is not satisfied, she argued, textbooks should give students opportunity to think and let them know they will later have another chance to learn it more clearly.
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Case of P2

P2, a prospective teacher, analysed the two textbooks in the light of the question Dowling asked in 2001, “What are the relationships between mathematics and non-mathematical practices such as shopping?” According to the report of P2, A and B, the two mathematics textbooks, used the market, bank, sports stadium, volunteer activity as contexts to show mathematics are used in ordinary life, and tried to reflect a mathematical system, a teaching objective, in each of those contexts. However, he felt the effort of naturally linking mathematics and non-mathematical practices failed in most cases; on the contrary, they caused the students to feel that mathematics is far from their everyday life. In the interview with the researcher he told the researcher like the following:

When we buy things in the market, we happen to face various discounting methods that even change at the will of the merchant at times. More importantly, we do not usually meet the situation where we have to go through a complex process of calculating the prices. In real life we confirm the prices of each article to buy one by one and then calculate the money to spend, rather than produce the price of an article by establishing simultaneous equations. Everything is done in a reverse order only in the mathematics textbooks. If the textbooks rely too often on the handling methods not used in everyday life, students will doubt all the situations depicted as every day life in their mathematics textbook.

In his opinion, offering a new world that students can come across only during the mathematics class is more effective that offering the conditions of everyday life in making students feel the usefulness of mathematics. His opinion was very unique and often collided with those of other students. He said he would reconstruct the textbooks in such a manner that, while analysing them, he would not pay attention to other conditions except for mathematical ones about the problematic situations he regards as unnatural.

Case of P3

P3, a prospective teacher, suggested that the textbooks and the teacher’s guide should be analysed using the mixture of many analysing methods and then the category-classifying method of Kulm et al. (2000) should be modified. He suggested the category 1 have two sub-standards of ‘1.1 Justifying the Sequences of Activities,’ and ‘1.2 Conveying Purpose.’ In his opinion, there is no need to divide unit purpose and lesson purpose and make a separate evaluation on them because ‘Justifying the Sequences of Activities’ is so much important. He also suggested that in the case of the category 3, ‘Providing Firsthand Experience’ be deleted or replaced. His theory is that, if firsthand experiences are emphasized too much in middle school mathematics, it might become more difficult for students to give attention to reasoning. He argued that though there are conditions where intuition or induction is to be emphasized; there also exist the conditions where attention should be paid to the progress in justification and reasoning; therefore, it is important to replace ‘providing firsthand experience’ with ‘Justifying the characteristics of activities.’
The following is a part of conversation between the researcher and P3:

1. R: What is the meaning of “Justifying characteristics of activities?”
2. P3: Activities contain a variety of characteristics. It is necessary to offer the kind of activities that fit the knowledge to be instructed. Rather than having the students engage themselves in activities unconditionally… How should I put it……? Sometimes, deductive reasoning, neither experimental nor inductive reasoning, can serve as an important point.

The participating prospective teachers confirmed that the contents provided in the textbooks reflect the results of considering many aspects, and in some cases, they found their users could be exposed to various dangers through the contents. More than anything, they agreed to the fact that prospective teachers themselves have to grow as active users of curricula and textbooks.

In the first discussion, a considerable portion of them believed there would be no errors in mathematics textbooks and accordingly, there was no need to reconstruct the contents of textbooks. However, in their final reports, all of them reached the conclusion that mathematical textbooks have merits in some aspects and demerits in other aspects--- incomplete products that need to be complemented by teachers. Also, they came to think conversion in teaching by textbook is just imaginary and rather, a desirable conversion in teaching can be completed by the teacher. This change in viewpoint means they have come to regard developing selectivity of textbooks as an important element of their specialty.

In most cases of reconstructing mathematics textbooks, the prospective teachers tried to utilize traditional costumes, folk games, etc.; and many attempts to apply technology were noted. P1, the prospective teacher, said “Even though mathematics has a long history, people in general are not aware of it, probably because it is not related to our native culture.” “The Study of Yut game,” developed by her seemed very suitable to be used in teaching the concept of probability, and actually the entire prospective teachers acknowledged its value most positively. She said she planned to study the reconstruction methods of textbooks all her life and maintained that a major part of class depends on teacher’s ability to reconstruct the textbook. On the other hand, it was found out that the prospective teachers were active in applying engineering to their reconstruction effort, which seemed to be because they are familiar with advanced cell phones and computers.

CONCLUSION

The participants of this research, who are prospective teachers, expressed the experience of participating in this research as “self-discovery as an expert,” “self-awakening to the difficulties of teaching” and “delicacy of converting knowledge,” etc. This means they perceived this research as a stage of growth to become a teacher. Particularly, this research played an important role in leading them to make an approach to the mathematics curricula and mathematics textbooks not merely as a passive user but a developer, or a user who is also a positive improver.
With the experience of reconstructing mathematics textbooks, the prospective teachers seem to have come into contact with the opportunity to perceive the characteristics of school mathematics. For the reconstruction, they were asked to confirm the contents that they had analysed in the past; and some participants, who keep making superficial criticisms with the unproductive viewpoint of analysis, were induced to reform their viewpoint of analysis in the process of reconstruction. This suggests that in educating prospective teachers, the cycle of textbook analysis and reconstruction should be continued on a steady basis.

The evaluation, analysis and reconstruction of mathematics textbooks require discreet and concrete approach. Attempts of this kind should also be made on a steady basis in educating incumbent teachers, which is believed to be one way of promoting conversation between researchers and teachers.

References


