ETHNOMATHEMATICS AND ITS EDUCATIONAL MEANING

A comparative analysis of academic discourse and educational use of mathematics history in Korea

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ABSTRACT

In this research, we comparatively analysed theoretical discourse in the research of mathematics history and educational use of mathematics history in mathematics textbooks to discuss implication for mathematics education in culturally diverse school. Our analysis focused on two kinds of documents: research documents of mathematics history published in Korea and Korean mathematics textbooks. Our analysis identified the tendency in which increasing numbers of Korean researchers adapt the perspective of mathematics as cultural knowledge. Parallel to the emergence of sociocultural discourse in the research of mathematics history, Korean mathematics textbooks introduce materials from the history of mathematics produced by diverse cultural groups. However, the Korean mathematics textbooks did not fully exploit the potential of mathematics history to bring up students' multicultural sensitivity. In Korean mathematics textbooks, use of mathematics history is still largely framed by the Eurocentric perspective on mathematics. This research has highlighted the significant discrepancy between the theoretical discourse of mathematics history and its educational use. This implies that it is essential to seek for ways of how to incorporate the issue of diversity and difference in educational use of mathematics history in textbooks.

1 Introduction

Recently, due to the increasing influx of immigrants, Korea undergoes a rapid transformation into ethnically and culturally diversified society. This cultural diversification demands fundamental restructuration of school education in Korea. In particular, nowadays an increasing number of immigrant kids enter Korean school and, as a consequence, school need to be prepared for students with various cultural backgrounds and to provide quality education that guarantees the equity in accessibility to all students. In this context, it is necessary to examine whether Korean mathematics textbooks are organized to be well-adapted into culturally diverse school. From the perspective, in this research, we comparatively analysed theoretical discourse in the research of mathematics history and educational use of mathematics history in mathematics textbooks to discuss implication for mathematics education in culturally diverse school.

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Research of mathematics history has shown that mathematics is a sociocultural and historical product and that mathematics has developed based on the dialogical relationship between diverse cultural systems of mathematics. We analysed mathematics textbook since they are regarded as documents that embody the educational visions of the national curriculum. Also, textbooks are essential teaching aid for teachers to plan and conduct their lessons in class. This implies that textbooks exert considerable influence on the teaching and learning of mathematics in school. Thus, it is of significance to investigate whether Korean mathematics textbooks are written to effectively exploit the potentials of mathematics history to address the educational needs raised by the cultural diversification in Korean school.

In addition to mathematics textbooks, we also analysed the theoretical discourse that has been raised in the research documents concerning history of mathematics. This analysis focused on the question of how the research of mathematics history in Korea has been changed in terms of its issues and theoretical discourse. Then, we compared the results of the textbook analysis and those of the research document analysis in order to investigate whether there are any connections or discrepancies between the perspectives about history of mathematics taken by the textbooks and by the research documents, respectively. Based on that, this research is to identify educational implication for the educational use of mathematics history in culturally diverse school.

2 Use of Mathematics History in Culturally Diverse Classroom

In the community of mathematics education, it has been argued that history of mathematics can play a valuable role in teaching and learning of the discipline (Fauvel, 1991). In fact, it is possible to locate historical quotations on the use of mathematics history in mathematics teaching and learning (Fasanelli, 2000). For instance, in his inaugural address as first president of the London Mathematical Society in 1865, de Morgan said:

> "I say that no art or science is a liberal art or a liberal science unless it be studied in connection with the mind of man in past times⋯The mathematician needs to know what the course of invention has been in the different branches of Mathematics; he wants to see Newton bringing out and evolving the Binomial Theorem by suggestion of the higher theorem which Wallis had already given. If he be to have his own researches guided in the way which will best lead him to success, he must have seen the curious ways in which the lower proposition has constantly been evolved from the higher" (recited from Fasanelli, 2000, p.35).

As this quotation suggests, mathematics educators have recommended that mathematics teachers creatively use history of mathematics in a variety of ways to teach mathematics. Especially, in the Korean national mathematics curriculum, educational use of mathematics history has been emphasized as one of methods for teaching and learning mathematics. Concomitant to this emphasis in the national mathematics curriculum, there has been a corpus of studies concerning the educational use of mathematics history.

In those documents such as national curriculum and educational theses, it is argued that history of mathematics reveals the connection between mathematics and human life and civilization. Thus, educational use of mathematics history can contribute to student motivation, the improvement of

students' affective attitude and beliefs about mathematics by highlighting the human aspect of mathematics. Moreover, it is considered that history of mathematics can be a good resource for mathematics teachers to plan their teaching because history of mathematics shows how mathematics has been evolved in terms of curiosities, insights, tasks, methods, difficulties, and achievements that mathematicians has come up.

Another educational significance of mathematics history lies in the fact that it brings up the issue of cultural diversity in mathematics class. In fact, mathematics historians have revealed that the mathematics is a cultural hybrid which has had a nomadic life across diverse civilizations (Joseph, 1993). This perspective adapts a fact that mathematics is totally integrated with other manifestations of a culture. Culture as a strategy for societal action manifests itself through jargons, codes, myths, symbols, utopias, and ways of reasoning and inferring. A community has historically developed practices such as ciphering and counting, measuring, classifying, ordering, inferring, modelling, and so on, which leads to a unique system of an ethnomathematics (D'Ambrosio, 2010).

This relationship between culture and mathematics extends our understanding of the educational significance of mathematics history. For instance, Horng (2000) comparatively analysed the methods used by Euclid and of Liu Hui to find the greatest common divisor of two natural numbers. The analysis has shown that ancient mathematics of the West and the East have approached common problems differently and made different contributions to the development of mathematics. Horng (ibid.) concluded that history of mathematics can be useful resource for teaching mathematics to students in a meaningful way. That is, by introducing other possible forms of doing things through history of mathematics, mathematics class can provide a context for students to approach mathematics from diverse epistemological and methodological perspectives. Mathematics teachers may help students appreciate the multi-dimensional splendour of the discipline and its relationship to other cultural endeavours (Siu, 2000).

From this perspective, ethnomathematics such as Egyptian multiplication, Polynesian way of calculating distance, or methods to measure land productivity used in traditional New Guinea are regarded neither as primitive nor as uncivilized. Rather, it is considered that these ethnomathematics is the culmination of the communal consciousness that have historically developed in the context of a community. Therefore, as students explore the history of an ethnomathematics, they learn the uniqueness of each cultural system of mathematics and the relationship between ways of living and ways of knowing. Grugnetti and Rogers (2000) argue that this multicultural approach to history of mathematics would help students escape from ethnocentrism and extend their mathematical perspectives beyond their own cultural backgrounds. The sociocultural perspective of mathematics challenges the hierarchical relation between European academic mathematics and other cultural mathematics systems and then reconstructs an egalitarian power structure among all these ethnomathematics. Thus, it is considered that research of mathematics history highlights cultural facets of the discipline and its use may create a context for students to appreciate different ways of doing mathematics and to learn how to communicate over the difference (D'Ambrosio, 2010).

So far, the discussion shows various potentials that history of mathematics can offer to school mathematics. It is necessary whether our school mathematics exploits all the potential of mathematics history for teaching mathematics to empower our students mathematically. From this perspective, we have analysed research documents in order to identify theoretical discourse that provides implication for educational use of mathematics history. Also, we analyzed Korean mathematics textbook in order

to investigate how effectively Korean mathematics textbooks are organized to address the issue of diversity. Based on the results of the comparative analysis, we will discuss educational implication.

3 Research Methods

3.1 Analysis of Theoretical Discourse in the Research of Mathematics History

In order to examine the research trends of thesis and articles about mathematics history published in Korea, we used representative searching engine provided by KERIS(Korea Education and Research Information Service). The reason why we chose the database of KERIS is that we focused on thesis and articles about mathematics history pulished in Korea and KERIS, as a governmental organization of Korea, has one of the most comprehensive database concerning research and publication of educational issues. Via the webside of KERIS, we searched thesis and articles by various keywords involving 'mathematics history', for example, 'Oriental history of mathematics', 'mathematics history of Chosun Dynasty', and 'Western history of matheamtics' as well as 'mathematics history' up to 2011. As a result of the search, we could locate 648 theses and articles published between 1970–2011.

We first classified data according to publication date in order to grasp the chronological changes in the issues of research. Then we classified them again into four categories according to research subject: General mathematics history (GMH), Western mathematics history (WMH), Eastern mathematics history involving Chinese and Japanese (EMH) and Korean mathematics history (KMH). If thesis and articles do not limit mathematics history regarding its origins, we sorted them into GMH. We counted materials dealing with Western mathematician, theories and approaches mainly to explain some mathematical theorem and principles produced by European mathematics to WMH. If thesis and articles deal with eastern mathematics history including Chinese, Japanese, or Korean mathematics history, we classified them as EMH. When as research document compared Western mathematics with Eastern or introduced Eastern mathematical development, solving problem process and literature, we categorized them into EMH. Thesis and articles concerning to Korean mathematics were categorized into KMH. Based on the categories, we analysed our data both qualitatively and quantitatively and described the tendency of how the theoretical discourse in the research of mathematics history has changed over the past five decades in Korea.

3.2 Analysis of Educational Use of Mathematics History

In order to investigate how mathematics history is used in Korean mathematics textbooks, we chose three mathematics textbooks for the 7th graders. These textbooks were selected because they were known as top ranked with respect to their portion in Korean textbook market. In Korea, a workbook accompanies a main textbook. So we analyzed both main textbooks and their workbooks. When we say "a textbook", it usually refers to a textbook with its workbook together, unless we specify which.

Based on theoretical literature, we constructed a preliminary frame for analysis and then applied it to the textbooks. Through the first pass of analysis, the preliminary frame was elaborated to fit better for our analysis. The final frame for analysis consists of factors of two dimensions, of which descriptions are following.

A. Origins of mathematics

The first dimension of the analytic frame is concerned whose history of mathematics is dealt with in textbook. We adapted the sociocultural perspective of mathematics so as to consider that European mathematics is not the only kind of mathematics. Based on the literature of ethnomathematics, we began with two categories that are concerned with European mathematics and non-European mathematics. After the preliminary analysis, we added the third category about the multicultural connection among ethnomathematics developed in many other nations, ethnics, racial groups. The multicultural connection refers to the pattern of use where the textbooks introduce materials from the history of culturally diverse mathematics to make a comparison or to integrate them to create a new of solving a problem. Therefore, this dimension consists of three categories: use of European mathematics history(EM), use of non-European mathematics history(NEM), and use of diverse ethnomathematics history for multicultural connection(MC).

B. Contents of mathematics history use

We also identified categories based on what kind of content is adapted from the history of mathematics. If textbooks introduced episodes of famous mathematicians, important mathematic problems, or historical anecdotes about mathematics, then we categorized them into C1. If textbooks present historical solutions or strategies about mathematical problems, we categorized them into C2. If a material from history of mathematics was used to provide a context for students to explore mathematical ideas and to develop their own mathematical thinking, then we categorize it into C3. Lastly, if a material from mathematics history is used to facilitate students to compare critically or to think creatively from perspectives of various ethnomathematics, then we categorized it into C4. C4 provides a context for students to approach mathematics from a multicultural perspective by comparing, deducing, creating based on the perspectives of diverse mathematics (Horng, 2000; Kim, 1999; Grugnetti and Rogers, 2000).

4 Findings

4.1 Theoretical *Discourse* in the Research of Mathematics History

We classified the collected research documents concerning history of mathematics and identified the frequency of WMH, EMH and KMH. Table 4.1 presents the results.

TABLE 4.1: The results of the frequency analysis

Period	Type								Total	
	WMH		OMH		WMH		GMH			
1970s	**1**	(0.1%)	**1**	(0.1%)	**2**	(0.3%)	-	-	**4**	(0.5%)
1980s	**4**	(0.6%)	**6**	(0.9%)	**5**	(0.8%)	**3**	(0.5%)	**18**	(2.8%)
1990s	**87**	(13.5%)	**5**	(0.8%)	**6**	(0.9%)	**10**	(1.5%)	**108**	(16.7%)
2000–2004	**176**	(27.2%)	**5**	(0.8%)	**11**	(1.7%)	-	-	**192**	(29.7%)
2005–2009	**236**	(36.4%)	**1**	(0.1%)	**16**	(2.0%)	-	-	**250**	(38.5%)
2010–2011	**68**	(10.5%)	**3**	(0.8%)	**3**	(0.5%)	-	-	**76**	(11.8%)
Total	**572**	(88.3%)	**23**	(3.5%)	**40**	(6.2%)	**3**	(2.0%)	**648**	(100%)

When we examine the above table more carefully, the number of the research documents on mathematics history increased rapidly over time. 88.3% of the research documents dealt with the history of Western European mathematics. Those documents introduced Western mathematicians as founder or developer of mathematical formula or algorithm. It can be said that those research adapts the Eurocentric perspective regarding that Western mathematics is the only legitimate kind of mathematics.

However, we found somewhat different position in Park(1977)'s thesis, which contained study on the history of Korean mathematics. She first compared the natural environment, industry, political and social structure, and ideology of Korea with those of China because she thought that all of those factors brought about different patterns of mathematical thinking and then examined the course of Korean mathematics. She argued that it needs more to establish formation process than accomplishments to understand truly mathematics of Koreans. This thesis shows that researchers of mathematics history began to recognize the relationship between mathematics and culture at that time using the concept of absolute mathematics. Especially, Park(ibid.) presented the necessity of research about Korean mathematics and explained that every nation has its own unique mathematics because of different climate, politics, economy, etc.

This point of view became extended in the 1980s. Researchers of the 1980s addressed viewpoints theoretically that they should get away from Western European mathematics traditions and regard mathematics as cultural heritage which belongs to every nation and ethnics by introducing the notion of ethnomathematics. With reference to the notion of ethnomathematics, Kim(1986) mentioned that every mathematics had contributed to the development of modern mathematics and that research trends was shifting from the history of European mathematics history to the history of the national and regional ethnomathematics. Hu(1997) also stated the differences around 1970 as follows: there were not only increasing number of literature on mathematics history but tendencies toward pluralist approaches reflecting a broad spectrum of mathematical concerns. Thus he referred lightly to literatures on the mathematics development in diverse societies like ancient China, India and medieval Muslim countries.

In the 1990s, theoretical researchers tried to establish the role and position of mathematics history in the mathematics education and emphasized the cultural value of mathematics. This effort had a great influence on the emergence of research on Korean mathematics history(Kim, 1999; Park, 2001). In the 1980s and the 1990s, in order to identify the status of Oriental mathematics, researchers tried to compare the Oriental mathematics and the Western mathematics by tracking their historical development. Researchers also sought to find the characteristics in the history of Korean mathematics that distinguish it from other Oriental mathematics, especially Chinese mathematics history. They were concerned to the fact that school mathematics included the knowledge of modern Western mathematics as only truth. Even mathematicians regard 'mathematics history' as Western European. This may lead students to think that there is no traditional mathematics in Korea. In fact, many people regarded Korean traditional mathematics as copies of Chinese mathematics. However, there are unique mathematics in Korea, so researchers investigated mathematical activities during the Chosun Dynasty in which many of historical artefacts remain.

At first researchers investigated the *Nine Chapters on the Mathematical Art*, one of the oldest ancient Asian mathematical books, which is a valuable material indicating that mathematics has existed with us for long time. Although it is from China, it can be said as significant part of Korean mathematics history in the regard that it influenced the formation of Korean mathematics. The Korean historical

mathematical books, for example, *Gu-il-jip*, *Iksan*, *Chugryangdohae*, etc. emerged around 1700 (Koh & Ree, 2009). The history showed how traditional Korean lived to reveal the existence of mathematical culture. This prompted researchers to investigate Korean mathematics history. Since mathematics of the Chosun dynasty accounts for a great part of Korean mathematics history, researchers explored mathematicians, mathematical terms and literatures of Chosun Dynasty. In the beginning, they ended up introducing anecdotes or life stories of mathematicians, and various problems. They extended the boundary of research to include the inquiry of the historic-genetic principle and solutions of specific problems.

In summary, research topics of mathematics history in Korea could be categorized into Western European mathematics history, Chinese mathematics history and Korean mathematics history. Here, most researchers of Chinese and Korean mathematics history have adapted the sociocultural perspectives of mathematics and emphasized issues about the cultural aspect of mathematical thinking and reasoning. They argue that every ethnic group and nation has its own traditional mathematics and that each group has contributed to the development of the world mathematics. In particular, researchers of Korean mathematics history tried to distinguish Korean mathematics from Chinese mathematics to emphasize the uniqueness of Korean mathematics.

4.2 Educational Use of Mathematics History

In order to examine the educational use of mathematics history in mathematics textbooks, we counted the frequency of each code as the mathematical contents C1, C2, C3, C4 which are categorized into European, non-European, and multicultural connection. In the following, we describe the salient features in the use of mathematics history in Korean mathematics textbooks

TABLE 4.2: The frequency of each code in the use of mathematics history

EM				NEM				MC				Total
67				31				39				137
(48.9%)				(22.6%)				(28.5%)				(100%)
C1	C2	C3	C4	C1	C2	C3	C4	C1	C2	C3	C4	
46	12	7	2	15	4	11	1	28	2	4	5	
(33.6%)	(8.8%)	(5.1%)	(1.6%)	(10.9%)	(2.9%)	(8.0%)	(0.7%)	(20.4%)	(1.5%)	(2.9%)	(3.6%)	

A. Use of anecdotes in mathematics history

In the analyis, we found that Korean mathematics textbooks use mathematics history in various ways. Among those ways of use, the most prevalent pattern of use was to introduce episodes and annnecdotes of famous mathematicians. As shown in TABLE 4.2, C1(64.9%) is the most prevalent throughout all the categories of the origins. In Korean textbook, mathematics history was most often used by introducing historical mathematicians and their mathematical achievements, artefacts, or events. They appeared on the first page of each chapter or as side readings in a chapter. This pattern of use simply list information without extending to the development of related mathematical ideas. In addition, TABLE 4.2 shows that most cases came from the history of European mathematics in this use of mathematics history.

Thus, the use of C1 may mislead students to think mathematics as an discipline that a few of genius mathematicians, especially, European male mathematicians, have produced. C1 in non-European

mathematics and muticultural connection introduced students about mathematics history of non-European societies. For instance, one of the textbooks introduced non-European mathematicians and female mathematicians as well as European mathematicians on the chronology of mathematics histroy. Although C1 in combination with the history of diverse ethnomathematics may contribute to revealing students that mathematics is universal knowledge. However, mathematics educators should be cautious of whether this use of mathematics history successfully highlight the cultural facet of each ethnomathematics.

Even though the textbooks attemped to connect ethnomathematics of diverse groups, they failed to create a sound mathematical connection. For example, one of the textbooks presented coins of diverse countries and posed a problems asking the relationship between the size of the angles. This question is rarely relevant to the purpose of expanding students' mathematical understanding of geometric shapes. Also, while the textbooks introduced annecdotes and artefacts from mathematics of diverse groups, they did not successfully highlight the diversity in the way of developing mathematical concepts.

B. Prevalence of European mathematics history

The analysis has shown that European mathematics history was prevalent in mathematics textbooks. The percentage of its use is 48.9%. It means that Korean mathematics textbooks were heavily oriented toward the European mathematics knowledge. For instance, while the mathematics textbooks introduced many mathematicians, they were mostly European male mathematicians like Euclid, Pythagoras, Decartes, etc. It is important to point out that the prevalence does not simply have a quantitative meaning. Instead, it is concerned with a postion whose mathematics is representative and legitimate. For instance, when the textbooks presented tasks to require students to explore mathematical ideas in connection to history of mathematics, the tasks mostly adapted history of European mathematics to guide students' exploration. So Korean mathematics textbooks represent European mathematics as a normative of students' mathematical development. This monocultural tendency contrasts to the theoretical discourse that Korean researchers of mathematics history has emphasized the understanding of cultural identity in the research of mathematics history.

C. Use of multicultural connection in mathematics history

Although the use of European mathematics history was prevalent, Korean mathematics textbooks tried to include historical materials from diverse cultural groups. As TABLE 4.2 shows, the percentage of non-European cateogory is 22.6% and the percentage of multicultural connection is 28.5%. However, although the textbooks tried multicultural approach by introducing historical anecdotes and artefacts from ethnomathematics of various groups, the mathematical achievement of non-European groups was hardly acknowledged.

For example, some tasks presented problem solving strategies taken from the history of western mathematics and from non-European mathematics and then asked students to compare them and to write the strength of the western style strategy compared to those of non-western strategies. In this way, most tasks in multicultural connection underestimate the ethnomathematics of non-European groups and mislead students to a monocultural view of mathematics which assumes rationality and efficiency of European mathematics as standard.

On the contrary, it is necessary to note that there were good examples of multicultural connection in the use of mathematics history. For instance, there was a task that introduced different solutions of the linear equation traditionally used in China and in Korea. The task asked students to discuss what the advantages and disadvantages of the different ways of solving the problem are. The strength of this task lies in the fact that it encourages students to faily compare mathematics of diverse cultural groups and to explore their mathematical values, benefits and contributions.

In multicultural connection, the mathematics textbooks did not effectively exploit the potential of educational use of mathematics history for bringing up students' understanding of difference and diversity. The tasks presented the mathematics history of diverse cultural groups in ways that implicitly or explicitly penetrate the taken-for-granted hierarchical relation between European mathematics as superior and non-European mathematics as inferior. Thus, it is of essence to seek for ways of how to introduce history of diverse ethnomathematics as highlighting their own cultural values and help students extend their mathematical perspectives as experiencing different ways of doing mathematics.

5 Conclusion

In this research, we comparatively analysed theoretical discourse in the Korean research documents of mathematics history and educational use of mathematics history in Korean mathematics textbooks to discuss implication for mathematics education in culturally diverse school. Our analysis identified the tendency in which increasing numbers of Korean researchers adapt the perspective of mathematics as cultural knowledge. In their research of mathematics history, they have developed a position that each cultural group possesses its own unique system of mathematics and a cultural system of mathematics grows through dialogical relation with other cultural systems of mathematics. This implies that Korea has developed a unique and distinct mathematics and that Korean mathematicians contributed to the development of world mathematics. The researchers have recommended to introduce Korean mathematics history into school mathematics in order to help our students acknowledge our traditional mathematics and develop high self-esteem of their cultural heritage.

Parallel to the emergence of sociocultural discourse in the research of mathematics history, the analysis of the Korean mathematics textbooks shows that mathematics textbooks introduce materials from the history of ethnomathematics produced by diverse cultural groups. However, the analysis has revealed that there was a significant limitation in the way of using history of mathematics. Specifically, Korean mathematics history was used as a tool to provide students with mere excitement, interest and motivation. Its use rarely extended to the development of mathematical meaning. More importantly, in Korean mathematics textbooks, use of mathematics history is still largely framed by the Eurocentric perspective on mathematics. So the Korean mathematics textbooks did not fully exploit the potential of mathematics history to bring up students' multicultural sensitivity.

The analysis of this research has highlighted the significant discrepancy between the theoretical discourse of mathematics history and its educational use. This implies that it is essential to seek for ways of how to incorporate the issue of diversity and difference in educational use of mathematics history in textbooks. When history of mathematics is fairly used, it will help students appreciate the cultural facet of mathematics and acknoweldge the unique strength and weakness of ethnomathematics created by a certain cultural group. Through this kind of cultural exposure to different ways

of doing mathematics, students may be encouraged to cross the boundary drawn by their own cultural background. As crossing the boundary, they may be encouraged to deconstruct and reconstruct knowledge hegemony taken-for-granted in society, and ultimately pursue freedom, equity, and peace via learning mathematics, which is the most valuable contribution that history of mathematics can make to mathematics education.

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