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Developing Mathematics Textbooks for the Teaching to Hearing Impaired Students of Junior High School

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Abstract

The study aims to develop mathematics textbook for the teaching of mathematics of both specialized and inclusive junior high schools. The study was a research and development (R & D) conducted through the following sequences: formulating characteristics through the learning observations, the theoretical reviews and the Delphi analysis; composing; performing the first trial; revising; performing the second trial; and revising, resulting in the final form of the textbooks. The results of the study are a mathematics textbook for the hearing impaired students in Junior High School that has been in accordance with the content standard for the hearing impaired students in junior high schools, and considered the students' characteristics and needs. In sum, the textbook are ready to be used for the teaching to the hearing impaired students of junior high school.

Keyword: hearing impaired students, junior high school, mathematics textbook

Mathematics has been very important for the mankind in living their life. However, mathematics has been notorious for being a very difficult subject, as indicated by the low students' learning achievements in it. The problem will be more complex especially for the hearing impaired students who try to learn and to understand the concept of mathematics under their limited communication capability; whereas, in fact they also have the same right to pursuit education.

The hearing impaired students have been widely spread in all layers of the community and they are less able to communicate with other community members. According to the National Association of the Deaf (2000), for the hearing impaired students their information processing is through their eyes, not through their ears, sign language, speech, amplification, and writing are some of their preferred methods of communication. The situation causes the hearing impaired students to have difficulties in their learning process. In relation to the situation, Adams and Holand (2006) state that disabled people do face additional barriers and challenges as they strive to continue their education. As a result, during the learning process there should be specific ways for having communication (Bouvet, 1990). Therefore, schools have an obligation in providing special service in order to ease the students to learn more easily. With regards to the mathematics that is abstract, the availability of textbooks for the mathematics teaching in the hearing impaired students should be given attention because these textbooks will assist the teachers in the teaching process so that the students will find it easy to understand mathematics concepts. In addition, these textbooks might also assist the government to implement the integrated education that guarantees the implementation of education for all.

One of the services provided for the disable students is the implementation of inclusive education (Fernie & Henning, 2006). Both in the inclusive schools and in the general schools that provide an integrated education system, information and facilities for the teaching of mathematics have been very minimum. The problems in the inclusive classes have not been handled (Healey, Bradley, Fuller, & Hall, 2006). Such conditions cause the schools to be unprepared in implementing the integrated education.

The teaching of mathematics to the differentable students has been conducted minimally and, thereby, mathematics becomes a more difficult subject especially for the hearing impaired students. The mathematics learning achievement, as the indicators of mathematics understanding, has not been satisfying for many parties. Therefore, there should be appropriate strategies for solving the problems and one of the viable solution might be

developing a mathematics textbook based on the hearing impaired students' characteristics and needs. In relation to the textbook development, there should be a mathematics textbook specifically designed for hearing impaired students in conducting the inclusive education.

In Indonesia, education is provided to all of the citizens, both the normal ones and the abnormal ones, both the ones who suffer from physical defect and the ones who suffer from the mental defect, without any discrimination. The education provided to the abnormal students – now regarded as students with special-needs – is called special education. Similar regulation also applies in the other countries such as Spain (Casas & Castelar, 2004), Italy (Cornoldi & Lucangeli, 2004) and Belgium (Dasoete & Armand, 2004).

The indiscriminative education has been based on the results of a conference held by the government of Spain in cooperation with the UNESCO (1994). The conference has resulted in the Declaration of Salamanca regarding the principles of policy and practice in the Special Needs Education and the main point of the Declaration is to expand the objectives of Education for All by paying attention to the shifts of fundamental policy necessary for the approach to inclusive education in order that the schools might be able to serve the students, especially those who have special needs.

The Declaration of Salamanca has formulated five statements (Stubbs, 2002) as follows. First, the Declaration reasserts the commitment toward the Education for All and admits the needs and the urgency for providing education to disable children, teenagers and adults in the regular education system. Second, the Declaration admits that each child has his or her own characteristics, interests, capabilities, and learning needs, which are different from one another and, therefore, the Declaration suggests that the education system should be designed and the education programs should be implemented by paying attention to diverse children's characteristics and needs. Third, the Declaration sets the principles of inclusive education as a policy so that all of the children will be enrolled to the regular schools except if there is a very strong reason for a different decision. Fourth, the Declaration suggests that all countries should demand the interest of the international people in supporting the approach to and the development of inclusive education as an integral part of the education programs. Fifth, the Declaration gives appreciation to the government of Spain and the UNESCO for their efforts to hold the conference and urges both to make any effort in distributing the declaration altogether with its action plan throughout the world.

In Indonesia, as stated in the lesson plan within the National Education System, the special education still faces difficult challenges that include the problems related to: (a)

expansion of learning opportunities for the learning participants who need the special education; (b) quality improvement; (c) relevance; and (d) efficiency. The sincerity of special educators in overcoming these challenges will reflect the democratic life of the nation that does not discriminate the citizens from one to another.

One group of the disabled citizens is the hearing impaired children. The hearing impaired children, like other human beings in general, are social creatures that need to have socialization and interaction with other people. The education for this type of children is an effort to develop the social skills and the children's independency so that they are ready to live normally and independently in sectors within the community (Mani, 2006).

One of the knowledge that should be mastered in the interaction among the community members is mathematics. For the normal students, mathematics has been considered as a difficult subject because it demands abstraction (Nuriana, 2007). The situation becomes worse because the students' achievement in mathematics is lower than their achievement in other subjects. For the hearing impaired students, the problems in the mathematics will be more complex. On the one hand, mathematics is an abstract concept and on the other hand, mathematics is necessary for living, however, it has been a difficult matter to communicate.

Casas and Castellar (2004) support these statements. They stated that in mathematics teaching by stating that in the mathematics learning the available textbooks only present the mathematics activities traditionally (exercises with stationeries), which use limited technology or method that goes beyond the minimal aspect of basic curriculum and if the mathematics textbooks are available usually they are still standard or are inappropriate for the special students' needs and characteristics. Based on these conditions, in the teaching of mathematics to the disable students, there should be special textbooks that will assist the teachers so that the hearing impaired students will easily understand mathematics concepts.

Regarding the fact that the education for the disable students has peculiar characteristics, there are several principles in conducting the education for the hearing impaired students. The education for the hearing impaired students should be based on the fact that the hearing impaired students have needs toward social affiliation namely affection, participation in social activities and acceptance by other people. In addition, the education for the hearing impaired students should be based on the hearing impaired students' needs and characteristics.

Physically, a hearing impaired child is not different from a normal child; however, people will find that a child is hearing impaired when he or she speaks. A hearing impaired child will speak without any voice or with unclear voice and the articulation is not clear, in some cases, a hearing impaired will not speak and, instead, he or she will only show gestures. A hearing impaired child is a child who suffers from hearing. Conversation impairment varying from 27dB to 40dB is categorized as “Very Low”, 41 dB to 55 dB “Low” category impairment, 56 dB to 70 dB “Moderate” category impairment, 71 dB to 90 dB “Heavy” category impairment and larger than 91 dB is categorized as deaf.

The hearing impairment will cause several disorders as having been stated by Abdurrahman and Sudjadi (1994). The disorders might be in the form of perceptual disorder, conversational disorder, communicational disorder, cognitive developmental disorder, social disorder, emotional disorder, and vocational problems. The core of these problems is the inability to have interaction with other people. In order to overcome these problems, many parties try to improve the participation of the hearing impaired children and to optimize their potentials by developing an integrated education at the junior high school level (Hallahan & Kauffman, 2000; Mani, 2006).

In relation to the education for the hearing impaired students, according to Hosni (2006), there should be several aspects that become the matter of consideration. These aspects are related to the principle of education conducted for the hearing impaired students, that the education should be conducted under the objective of rehabilitating the hearing impaired students’ hearing sense and of developing their communication skills by means of a good educational management. Within an educational environment, a hearing impaired child needs assistance in order to socialize with a normal child and to minimize the other impacts such as being left behind in the academic domain (Brackett, 1994).

The main problem that the hearing impaired children have is the lack of hearing capability, which leads to the lack of communication ability. The lack of communication ability is also caused by the lack of language proficiency that these students possess. These lacks should be the teachers’ attention and within the learning process the teachers should be close to the students (Kirk & Gallagher, 1986; Hallahan dan Kauffman, 2000). In relation to the textbook, the textbook provides great contribution toward the learning success (Sahertian, 2004); an appropriate textbook might be selected in order to assist the problem solving process.

Mathematics as a fundamental science recently has developed rapidly both in terms of material and of usage. Mathematics has been important knowledge for developing the science and technology (Kamil, 2006). Therefore, in the teaching process at schools should pay attention to the development of mathematics either in the past, in the present or even in the future. Mathematics that has been taught in the elementary school and junior high school and in the senior high school is usually regarded as school mathematics (Soedjadi, 2007, p. 37).

Mathematics as one of the subjects taught in schools has certain characteristics. According to Soedjadi (2000, p. 13), several characteristics of mathematics are as follows: (a) having objects of abstract review; (b) being based on agreement; (c) having deductive thinking pattern; (d) having meaningless symbols; (e) paying attention to the universe of conversation; and (f) being consistent in the system. Then, the function of mathematics is to serve as a tool, a paradigm, and science or knowledge (Suherman, 2003, p. 76). For the students, learning mathematics should be habituated in order to have experiences from understandings or reasonings toward a relationship among the understandings or the reasonings. Therefore, the students should be made accustomed to gaining understanding by means of having abstract experiences regarding the characteristics that have been possessed and that have not been possessed by a group of objects. Based on the observation, the students are also expected to be able to catch the understanding of a concept. The students are also trained to make prediction, assumption or tendency based on their experience or their knowledge.

Mathematics has been very important knowledge for the mankind since mathematics has been an integral part in their daily life (Fathoni, 2006). One of the characteristics of mathematics is that mathematics has abstract objects. The abstract characteristic causes many students to have difficulties in learning mathematics. The students' mathematics achievements both nationally and internationally have not been satisfying. The low students' mathematics achievement is caused by the students themselves; they have comprehensive problems or partial problems in understanding mathematics. In addition, the students' mathematics learning process has not been meaningful so that their understanding of the concept has been weak.

Jenning and Dunne (1999) state that most of the students have difficulties in applying mathematics into of real life situation. Another matter that causes the students' difficulty in studying mathematics is that mathematics teaching has not been meaningful. The teachers during the process of teaching mathematics in classes do not associate the subject to the

schemes that the students have and the students are given opportunities to regain and reconstruct the mathematical ideas on their own. Associating the students' concrete experiences to the mathematical ideas in the learning process should be done in order that mathematics teaching will be more meaningful (Price, 1996; Soedjadi, 2000; Zamroni, 2000). According to Van de Henvel-Panhuizen (2000), if the students learn mathematics separately from the experiences in their daily life, they will quickly forget the mathematical concepts and will not be able to apply the mathematical concepts.

Mathematics is notorious for being a difficult subject, especially for the hearing impaired students. For them, the problems of mathematics learning will become more complex because mathematics contains abstract symbols and graphics. The abstract characteristic causes mathematics to be difficult to communicate. The efforts to improve the understanding of the mathematical concepts within the hearing impaired students will also be hard to make (Morimoto, 2006). On the one hand, mathematics has been a necessity in the daily but, on the other hand, mathematics has been an abstract concept that is difficult to be understand and to communicate. Therefore, there should be interventions in order that the students do not have difficulties within the mathematics learning (Nunes, 2004).

The emphasis in mathematics teaching is on problem solving. For the hearing impaired students, there are special strategies in the problem solving activities. According to the National Technical Institute for the Deaf (NTID), the strategies for problem solving activities are as follows: (a) giving an explanation to a peer observer in sign language, after which they would put their understanding of a problem and its solution in writing, (b) visualizing the problem solving process prior to starting to solve a problem, and (c) observing their teacher modeling the analytical process step by for a sample problem prior to solving math word problems (Mousley & Kelly, 1998). These strategies should be considered in designing a textbook for the hearing impaired students.

In textbook development, there are several principles that should be given attention to. The first principle is relevance. The learning materials should be relevant or be associated to the achievement of the competence standards and the basic competencies. The second principle is consistence. If the students have four basic competencies that should be achieved, then the textbooks should have four competencies to be taught. The third principle is sufficiency. The learning materials should be sufficient enough in assisting the students to master the basic competencies that will be taught. The given learning materials should not be too few nor too many.

Since mathematics is abstract, in order that its concept to be easier to understand the subject should be presented concretely. The perception is supported by Jeening & Dunne (2000) as well as Van del Henvel Panhuizen (2000); these researchers state that the mathematics teaching process should be made more meaningful so that the students will have more in-depth understanding. In other words, the textbooks that will be developed and will be used in teaching mathematics should be presented more concretely.

The mathematics textbook should consider the hearing impaired students' characteristics who have problems with verbal capability. These problems might be bigger because in education, communication and language hold an important role (Morimoto, 2007). As a result, it will be difficult for hearing impaired students to understand mathematics learning materials. In order to overcome these problems, the special/mathematics education experts and the previous researchers provide several suggestions as follows: (a) concrete learning materials should be used (Pagliaro, 2008); (b) the learning dimensions should be simplified regarding the fact that hearing impaired students are only able to understand a single dimension (Ottem, 1980); (c) there should be problem solving activities within the learning process (Mousley & Kelly, 1998) and problem solving activities should be presented in a simple manner because hearing impaired students have limited language proficiency (Pau, without year); (d) mathematics ideas should be conceptualized and be visualized by means of experiences (Morimoto, 2007); (e) hearing impaired students find it difficult to interpret diagrams and graphics, therefore diagrams and graphics should be made simple (Morimoto, 2007); and (f) models and illustrations might help focusing hearing impaired students' attention to reorganize the information (Mayer, 1989).

Method

This research was research and development (Borg, 1981). The development of the mathematics textbooks intended for hearing impaired students within the implementation of integrated education in the junior high school was conducted through the following phases: (a) formulating the characteristics of the textbook that would be intended for hearing impaired students of the junior high school by performing literature review, learning observation, and Delphi analysis; (b) composing the mathematics textbooks intended for hearing impaired students of junior high school under the framework of integrated education; (c) performing the first stage trial toward the mathematics learning textbooks; (d) revising the mathematics textbooks based on the results of monitoring and evaluation in the first stage trial; (e)

performing the second stage trial toward the mathematics textbooks in a wide scale; and (f) revising the mathematics textbooks based on the results of monitoring and evaluation in the second stage trial. The final result of the study was the textbook intended for the teaching of at the junior high school.

In general the data gathering method in the second stage of the study used three complementary methods namely: (a) observation, which would be conducted in order to identify the problems that occurred during the teaching of mathematics to the hearing impaired students in the integrated education of junior high school in relation to the needs of textbook, and the observation was conducted in order to gather the data regarding the use of the developed textbook; (b) Delphi, which would refer to a technique for gathering opinions from mathematics teachers, principals, school supervisors, mathematics education experts, and hearing impairment experts in formulating the characteristics of the textbook intended for hearing impaired students and in predicting these characteristics in the future altogether at the same time; and (c) interview, which would be conducted to the hearing impaired students who made use of the textbooks, to teachers, to principals, to school supervisors, to mathematics education experts and to hearing impairment experts in order to gain feedbacks for the textbooks during the trial. The gathered data would be analyzed by means of the qualitative descriptive analysis.

Findings

Based on the needs analysis, both in the observation of mathematics teaching at the junior high school and in the Delphi of the mathematics teachers, the principals, the school supervisors, the mathematics education experts and the expert in hearing impaired student education, and by paying attention to the characteristics of mathematics textbook for hearing impaired students, theoretically the researchers found the characteristics of the necessary textbook. These characteristics include: (a) in the beginning of every chapter, the textbook would display interesting figures that might trigger hearing impaired students' learning motivation; (b) the textbook contains title, competence standard and basic competencies that hearing impaired students should achieve; (c) the textbook contains the outline and the contextual problems by means of hearing impaired students' experience that would lead to learning materials; (d) the textbook refers to the content standards, that should meet the competence standard and the basic competencies for the specific-hearing impaired students of junior high schools; (e) the textbook displays pretests in order to test hearing impaired

students' preliminary ability in the related chapter; (f) the textbook displays the mathematics concept in a simple manner and these concepts are visualized first by using colorful pictures; (g) the textbook displays the public figures related to the learning materials and the stories of the related public figures would lead the hearing impaired students to contemplate more about the learning materials; (h) the textbook would give certain Web addresses in case the hearing impaired students would explore the learning materials more; (i) the textbook would contain the use of technology as an assisting tool in mathematics learning, such as calculator and computer; (j) the concept displayed in the textbook would be highlighted so that the students would easily find these concepts; (k) the textbook would contain the problem solving activities altogether with the examples and the practices; (m) the textbook would contain summary, material review, and project assignment in order to assist the construction of concept understanding; and (n) the textbook would contain a concept map in order to understand the structures of the materials that would be displayed. These characteristics would be made as the basis in designing the mathematics textbook for the specific-hearing impaired students of junior high schools from the seventh grade to the ninth grade. The context of the textbook would refer to the standards of specific hearing impaired students of junior high school mathematics learning content provided in the Indonesian national curriculum and the standards are shown in Table 1, and the division of the textbook is shown in Table 2.

Table 1
The Aspects of Mathematics Learning Textbook for he Hearing Impaired Students

Class	Semester	Aspect	Basic Competence
VII	1	Number	Understanding the number in fraction
		Algebra	Understanding a single linear equation and inequation Accomplishing algebra operation and comparison in the problem solving
	2	Algebra	Understanding the concept of association in the problem solving
		Geometry and Measurement	Understanding the relationship between line and line, line and angle, angle and angle altogether with the measures Understanding a triangle and a rectangle
VIII	1	Algebra	Understanding the algebra in the problem solving
		Geometry and Measurement	Understanding the theorem of Phytagoras in the problem solving Understanding the elements and the parts of a circle
	2		Determining the measures that are related to a circle Understanding a cube and a crossbar along with the parts
		Geometry and Measurement	Understanding the congruency of planes
IX	1	Probability and Statistics	Understanding a cylinder and a cone Processing the data in determining the probability of a simple event
	2	Bilangan	Understanding the row and the line of numbers for problem solving

Table 2
The Chapter Division of the Mathematics Textbook for the Hearing Impaired Students

Class	Semester	Chapter
VII	1	Number Single Variable Equation and inequation Algebra Form
		Ratio Association
	2	Line and Angle Triangle Rectangle
		Quarter dan Factor
VIII	1	Relation and Function Theorem of Phytagoras
		Circle
	2	Cube and Crossbar Triangle Uniformity
IX	1	Cone Probability and Statistics
	2	Pattern of Number

After the textbook content had been designed according to the characteristics, it was put into trial and the trial involved the experts, in order to gain the readability, and the junior high school hearing impaired students. The trial was performed twice at different schools and each of the trial was accompanied by revision.

The first trial was performed in Yogyakarta exclusive junior high school. The readability of the mathematics textbook that had been designed was tested by the teachers and the students and the readability then was reviewed by the experts in education for the people with hearing impairment. The trial was conducted in order to gather the feedbacks from the mathematics teachers, the hearing impairment experts and the mathematics education experts.

The feedbacks provided by the mathematics teachers of Yogyakarta exclusive junior high school were as follows: (a) the cover of the textbook should be made interactive and communicative; (b) the learning materials within the textbook had been sufficient, however the sentences were still too long and, as a result, the students had difficulties in understanding the concepts; (c) the textbook had been put into trial toward the students and some of the students were able to do the exercise while the some others were not due to the concept understanding from the previous chapters; and (d) the textbook should be simplified in terms of both the explanation of materials and the exercise.

The feedbacks from the mathematics education experts were as follows: (a) in terms of originality, the learning materials in the textbook had been sufficient and the concepts had been good; (b) the textbook setting should be made more interesting, for example by adding the variation of colors; (c) the displayed graphics and pictures had been clear; and (d) with few revisions, the textbook might be used for facilitating the hearing impaired students whose hearing capability is low.

The feedbacks from the experts are education for people with hearing impairment were as follows: (a) several descriptions and material discussions should be simplified; (b) all of the pictures should be displayed with more colors; and (c) the textbook could be used for the teaching of mathematics. Based on these feedbacks, the researchers revised the textbook and the textbook was then put into the second trial.

The second trial was conducted at Widya Dharma Inclusive Junior High School located in Tempel, Sleman, and Yogyakarta. The textbook that had been designed was put into trial and the trial involved the mathematics teachers and the hearing impaired students. The mathematics textbook was also reviewed by the principal, the school supervisor, a

mathematic education expert and an inclusive education expert. From the results of the second trial, the principal and the mathematics teachers provided the following feedbacks: (a) the book readability in overall was better than the compulsory textbook, however the special-need students still took longer time than the normal students did and this aspect should be given attention by the teachers; (b) the colors helped the students more in understanding the learning materials (in differentiating the material emphasis); (c) the textbook heading was better than the usual compulsory textbook, but the words that might cause ambiguous meaning should be kept simple or should be given more explanations in brackets; (d) several parts of the textbook should be revised in order to make students understand the materials more easily; (e) in comparison to the usual compulsory textbook, the hearing impaired students admitted that the researchers-designed textbook was easier to understand and, therefore, the students expected that the textbook would be developed; (f) the colors and the pages in the textbook were sufficient; and (g) the textbook layout was interesting.

The school supervisor, the mathematics education expert and the hearing impairment education expert supported the results of the trial that had been conducted in the schools; basically, the designed was good and was in accordance with the content standards and the hearing impaired students' characteristics. The display of problem solving activities and the exercises became enrichment materials for the students so that they would have sufficient capability in pursuing the in-depth understanding.

The feedbacks provided by the students, the teachers, the principals, the school supervisors, the mathematics education experts and the hearing impairment education experts were then used as the basis for revising the mathematics textbook. The results of the revision were the textbook for the teaching of mathematics textbook to the hearing impaired-students of special junior high schools from grade VII to grade IX.

Discussions and Conclusions

In this study, the researchers have been successful in developing a mathematics textbook for the hearing impaired students of the junior high school and the mathematics textbook has been in accordance with the content standards of hearing impaired-student specific junior high school; the mathematics textbook has also considered the hearing impaired students' characteristics. The hearing impaired students' characteristics are as follows: (a) in the beginning of every chapter, the textbook displays interesting figures that might trigger their motivation; (b) the textbook chapters contain title, competence standard,

and basic competencies that the hearing impaired students should achieve; (c) the textbook contain the outline and the contextual problems by means of the hearing impaired students' experience that would lead to the learning materials; (d) the textbook refers to the content standards that should meet the competence standard and the basic competencies for the specific-hearing impaired students of junior high schools; (e) the textbook displays pretests in order to test the hearing impaired students' preliminary capability in the related chapter; (f) the textbook displays the mathematics concepts in a simple manner and these concepts are visualized first by using colorful pictures; (g) the textbook displays the public figures related to the learning materials and the stories of the related public figures lead the hearing impaired students to contemplate more about the learning materials; (h) the textbook gives certain Web addresses in case the hearing impaired students would explore the learning materials more; (i) the textbook contains the use of technology as an assisting tool in their mathematics learning, such as calculator and computer; (j) the concept displayed in the textbook is highlighted so that the students would easily find these concepts; (k) the textbook contains the problem solving activities altogether with the examples and the exercises; (m) the textbook contains the summary, material review, and project assignment in order to assist the construction of concept understanding; and (n) the textbook contains a concept map in order to show the structures of the materials that are displayed.

The mathematics textbook has also been put into trial by involving the students, the principals, the inclusive junior high school supervisors from the Office of Education, the Province of Yogyakarta Special Region, the mathematics experts, and the inclusive education experts. The final results of the study is a textbook that is ready to be used for in the teaching of mathematics learning to the hearing impaired students of the junior high school.

Regarding the limited numbers of hearing impaired students in the special junior high school for the hearing impaired-students in the Province of Yogyakarta Special Region, the trials in the study were conducted only in two junior high schools. A wider-scale is necessary to be conducted in other special junior high school for hearing impaired-students. In addition, the study has only developed a mathematics textbook for the hearing impaired students. Therefore, the future studies might develop mathematics textbook for the students with other disabilities such as the gifted students, the autistic behaviour students, the blind students, and alike.

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