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Realistic Mathematics Textbook Toward The Students' Mathematical Generalization Skills

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Abstrak

Generalisasi merupakan ciri siswa dapat berpikir matematis. Guru dapat mengembangkan bahan ajar berbentuk buku teks untuk memfasilitasi kemampuan generalisasi. Penelitian ini merupakan hasil pengembangan model ADDIE yaitu tahap penerapan dan evaluasi, dengan produk berupa buku teks matematika kelas VIII semester genap yang berorientasi pada kemampuan generalisasi matematis siswa. Buku teks dengan pendekatan Pendidikan Matematika Realistik (RME) ini memuat lima prinsip meliputi eksplorasi fenomenologi, menjembatani dengan instrumen vertikal, kontruksi dan produksi siswa, interaktivitas, dan keterkaitan. Melalui alur kegiatan pemberian lebih dari satu konteks permasalahan, identifikasi kesamaan pola atau strategi hingga penarikan kesimpulan terkait materi, serta pemberian latihan soal pemodelan, buku teks ini telah memfasilitasi kemampuan generalisasi matematis. Berdasarkan hasil penerapan buku teks yang melibatkan 30 siswa kelas VIII salah satu SMP Negeri di Yogyakarta, persentase banyaknya siswa pada kategori good memenuhi batas minimal 75% yaitu mencapai 93,33%.
Kata Kunci: Buku Teks; Kemampuan generalisasi; Pendidikan Matematika Realistik.

Abstract

Generalization is a feature that students can think mathematically. Teachers can develop teaching materials in the form of textbooks to facilitate generalization abilities. This study was the developmental stage of ADDIE model, namely the implementation and evaluation. The study produced a textbook for 8th grade even semester which was oriented to students' mathematical generalization skills. The textbook integrating a realistic mathematics education approach contained five principles including phenomenological exploration, bridging by vertical instruments, pupils' own constructions and productions, interactivity, and intertwining. The flow of activities provided more than one problem context, identifying similarities in patterns or strategies to draw conclusions related to the material as well as modeling exercises to facilitate students' mathematical generalization abilities. Based on the results of textbook implementation involving 30 8th grade students from one of a state junior high school in Yogyakarta, the percentage of students in good category met the minimum point of 75%, which reached 93.33%.
Keywords: Generalization Ability; Realistic Mathematics Education; Textbook.

I. Introduction

Generalization is the heartbeat of mathematics (Nurmawanti & Sulandra, 2020). If the teacher is not aware of generalization skills or students are not able to express their generalization thinking, the learning process does not demonstrate mathematical thinking (Mason, 1996: 65-66). As part of mathematical reasoning, generalization is not only dealing with the result but also the process because it serves the basis of mathematical concepts and ideas (Mata-Pereira & Ponteira, 1996; Suwanto & Wijaya, 2018). Thus, mathematical generalization is the ability to process and seek the resolution as the products of students' reasoning on the mathematical concepts and ideas in a general context.

Students with generalization skills will be able to combine their knowledge and experience. This combination is a creative process to construct a solution to a given problem (Hashemi et al., 2013: 212). In other words, the ability to generalize allows students' knowledge to be broader and transformed into practical knowledge (Hayuningrat & Rosnawati, 2022).

The results of TIMSS (*Third International Mathematics and Sciences Study*) in 2011 ranked Indonesian 8th grader at the lower category, namely 38th out of 42 participating countries (Mullis et al., 2012: 150; Mulyo, Sari, & Syarifuddin, 2019). This shows that the implementation of the education, especially in the field of mathematics, has not been fully utilized (Tomy, Maimunah, & Yenita, 2021; Nurhasanah, Syafari, & Nurfaidah, 2022; Syaputra, Hidayati, & Hasanah, 2023). Furthermore, the reasoning skill of Indonesian students is also relatively low with an average of 388, and this is far below the international average score of 500 (Mullis et al., 2012: 150). As generalization is associated with a form of inductive reasoning, it indicates that students' mathematical generalization skills are also still in the low category.

As part of the scope of mathematics learning and a critical role in problem solving skill, the students' generalization skills must be continuously improved. This improvement can be facilitated through the development of learning support tools, one of which is teaching materials such as textbooks (Yulianto, Sisworo, & Hidayanto, 2022; Auliya' & Widjajanti, 2023). Textbooks as a reflection of the school curriculum are a good source to provide learning opportunities and at the same time a good indicator to measure students' mathematics learning opportunities (Yang et al., 2017: 2841-2842; Wardana & Damayani, 2017).

The demand for textbook development to facilitate student mathematical generalization ability is also supported by several reasons. First, the available textbooks do not facilitate mathematical generalization ability because they are too procedural and do not provide opportunities for students to do modeling activities and low reflective tasks Panhuizen, (2003: 51-60). Second, there are only few teachers who develop their own learning textbooks. The evidence is represented by the lower percentage of the teachers who use their own modules. 86% of grade VIII junior high school mathematics teachers in Yogyakarta are using math textbooks provided by the government as a reference and guide in the learning process (Suwanto

& Wijaya, 2021: 45). Third, based on the results of a questionnaire given to junior high school mathematics teachers in Yogyakarta, it revealed that no teachers have developed a textbook oriented to students' mathematical generalization ability (Nurhikmayati & Jatisunda, 2019).

One of the constructive approaches that can be applied to textbooks to develop students' mathematical generalization skills is Realistic Mathematics Education (RME). This approach uses real world contexts of everyday life and provide problems that students can envisage as the basis of mathematics learning (Afriansyah, 2016). Thus, the students are involved in a meaningful learning process (Hadi, 2017: 37; Fitri, Fitri, & Jufri, 2022).

Gravemeijer (2010: 43) defines RME as an interactive teaching theory between teachers and students or among students, centered on certain problems to support students to build or rediscover mathematical concepts. Through this approach, the teacher emphasized its role as a facilitator while students actively proceed to the social context of the classroom to discover or rebuild mathematical concepts (Zaneta, 2022). This rediscovery of mathematical concepts is related to the term mathematization.

Mathematization can be defined as the process of representing realistic models into mathematical language (Suwanto & Wijaya, 2018: 304; Afriansyah, 2022). It is divided into two types, namely horizontal mathematization and vertical mathematization. Horizontal mathematization is known as the process of using models to solve specific problems, whereas using these models to make generalizations, formalizations, is known as vertical mathematization (Dickinson et al., 2011: 48). Progressive mathematization in RME, both vertically and horizontally, is based on five teaching principles stated by Treffers (1987: 248-250). They are phenomenological exploration, bridging by vertical instruments, pupils' own constructions and productions, interactivity, and intertwining (Mutiarahman, Edriati, & Suryani, 2023).

Through phenomenological exploration, the learning process begins with providing real problems in the textbook to foster students' mathematical generalization skills. This is in line with NCTM (2000: 335) who revealed that mathematical generalization could be introduced effectively by giving problems that helped students see important aspects of the idea to be generalized.

Furthermore, through bridging vertical instruments, students’ construction and production, interactivity, and intertwining by emphasizing analogy, classification, and structure in mathematics learning can also facilitate students' mathematical generalization skill. This demonstrates that generalization is a mathematical process in RME itself which is related to patterns and relationships (Wijaya, 2012: 42). Thus, the textbook developed from the principles of the RME approach is expected to indirectly facilitate students' mathematical generalization skill.

In addition, Jupri, Usdiyana, & Sispiyati (2020: 105) stated that RME principles in the form of reality, levels, and linkages can be used to develop teaching materials on numerical pattern material. One of the learning activities contains generalization of numerical patterns that facilitate students' mathematical generalization skills. Therefore, the development of teaching materials in the textbooks to improve students' mathematical generalization skills can be conducted by applying RME principles.

II. METHODS

This research is two of the five results at the developmental stages of the ADDIE model *(Analysis*, *Design, Development*, *Implementation*, *Evaluation)* adapted from (Branch, 2009), namely the implementation and evaluation stages. The the study produced a mathematics textbook for junior high school students in grade VIII for even semester with RME approach. The effectiveness of the textbook in facilitating students' mathematical generalization skills was investigated through a test instrument given to 30 students of one of the VIII classes of a Junior High School in Yogyakarta in the even semester of the 2017/2018 academic year. The descriptive test was presented after the trial of the textbook had been developed at the implementation stage. The quantitative data of the test results obtained were then analyzed at the evaluation stage using the conversion presented in Table 1 (Widoyoko, 2017). The developed book was said to be effective if the test results of students' mathematical generalization ability were at least 75% in the good category.

Table 1.
The Conversion of Quantitative to Qualitative Data

Interval Skor	Kategori
$X > \bar{X}_i + 1.8 \times sb_i$	Very good
$\bar{X}_i + 0.6 \times sb_i < X \leq \bar{X}_i + 1.8 \times sb_i$	Good
$\bar{X}_i - 0.6 \times sb_i < X \leq \bar{X}_i + 0.6 \times sb_i$	Average
$\bar{X}_i - 1.8 \times sb_i < X \leq \bar{X}_i - 0.6 \times sb_i$	Below average
$X \leq \bar{X}_i - 1.8 \times sb_i$	Poor

Note:
$\bar{X}_i$ = perfect mean
sb_i = perfect standard deviation
X = empirical score

III. RESULT AND DISCUSSION

The even semester junior high school mathematics textbook developed from the RME approach consisted of five chapters (main materials), namely the Pythagorean Theorem, circles, flat-sided spaces, statistics, and probability. The quality of this textbook not only met the validity and practicality criteria (Suwanto & Wijaya, 2021) but also the effectiveness criteria to foster students' mathematical generalization skills. This effectiveness were demonstrated by the results at the evaluation stage after the implementation.

Figure 1. The Distribution of The Textbooks to The Students

The implementation of the textbook in the pilot class involving 30 junior high school students in grade VIII was successfully conducted. After the distribution of textbooks to each students' group (see Figure 1), students were asked to do and discuss the activities contained in the book.

Students' engagement in the activities is presented in Figure 2.

Figure 2. Students Discussing the Activities in The Textbook.

After the pilot class, the generalization test wad provided to test the textbook effectiveness on the students. The result of the test is provided in Table 2.

Table 2.
The Students' Generalization Skills

Category	Number of students	Percentage	Average
Very high	16	53.33 %	79.93 (High)
High	12	40 %	
Average	2	6.67 %	
Below average	0	0 %	
Poor	0	0 %	

Table 2 shows that the average value of students' mathematical generalization skill is relatively high, namely 79.93. There were no students in the below and poor categories, but there were few in the average and high categories. In the average category there are only 2 students with a percentage of 6.67%. The rest, 12 students were in the high category and 16 students were in the very high category with a percentage of 40% and 53.33% respectively. The number of students who were at least in the high category is 28 students with a percentage of 93.33%> 75%. Thus, the developed product was considered effective in terms of students' mathematical generalization ability.

Table 3.
The Indicators of The Students' Generalization Skills

Indicators	Average	Categories
Identify the nature of an object or phenomenon	3.43	Very good
Identify the similarity of an object, trait, or situation	3.62	Very good
State the rules, patterns, strategies, or ideas of an object or phenomenon	3.48	Very good
Define an object that meets a given relationship, pattern, or phenomenon	2.40	Average
Use general ideas or strategies to solve problems	3.50	Very good
Modify general ideas or strategies to solve problems	2.75	Good

Then, the analysis of the effectiveness in terms of mathematical generalization skill was derived from the percentage of indicator achievements. Based on Table 3, the highest average score obtained by students was 3.62. This showed that the students considered identifying the similarity of an object, trait, or situation as the simplest activity. While the lowest overall average score obtained by students was 2.40. This meant that students considered defining an object that fulfills a given relationship, pattern, or phenomenon as the most complex one.

Table 4.
The Relationship of The Indicators of Mathematical Generalization Skills and The Principles of RME

Indicators	The principles
Identify the nature of an object or phenomenon	Phenomenological exploration, intertwining
Identify the similarity of an object, trait, or situation	Through interactivity:

State the rules, patterns, strategies, or ideas of an object or phenomenon	bridging with vertical instruments, students' construction and production, intertwining
Define an object that meets a given relationship, pattern, or phenomenon	
Use general ideas or strategies to solve problems	Students' construction and production
Modify general ideas or strategies to solve problems	Students' construction and production, intertwining

The effectiveness of the RME-oriented textbook to the mathematical generalization skills was certainly inseparable from the implementation of the principles of the approach itself (Note Table 4). Through the application of phenomenological exploration of using context in the book, the students were facilitated to connect two or more problems, situations, ideas, or mathematical objects related to the material being studied (see Figure 3). In other words, this encouraged students to be able to identify the natures of an object or phenomenon.


Statistika berkaitan erat dengan data. Data sensus penduduk, data laporan hasil belajar, data pengunjung perpustakaan maupun data lainnya dapat disajikan dalam berbagai bentuk dengan statistika. Bentuk-bentuk penyajian ini dimaksudkan agar memudahkan pembaca menganalisis data yang disajikan. Perhatikan beberapa penyajian data berikut ini!

Tekomnet

Dengan menggunakan Micosoft Excel, kita bisa menentukan nilai terkecil dari suatu data menggunakan bentuk fungsi disertai argumen, yaitu:
=MIN(number1;number2;...)
Keterangan:
Number = Data angka, sel atau *range* yang berisi angka.

Tabel 4.1 Ekspor-Impor Beras Indonesia

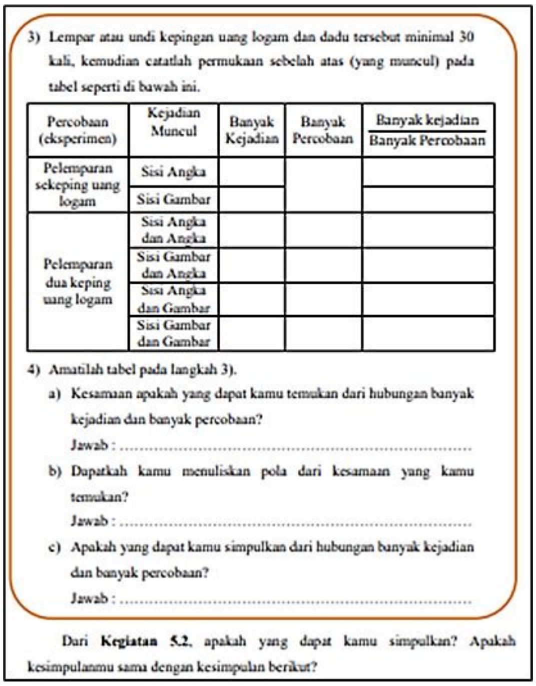
Periode	Berat Bersih (Kg)	
	Ekspor	Impor
2014	516.069	844.163.741
2015	519.497	861.601.001
2016	999.167	1.283.178.527
2017	2.531.551	256.599.605

Sumber: https://www.bps.go.id

Tabel di atas menunjukkan bahwa dari tahun 2014 hingga 2017, banyak beras yang diimpor Indonesia lebih besar daripada yang diekspor. Impor beras terbesar terjadi pada tahun 2016 yaitu sebesar 1.283.178.527 kg. Pada tahun berapakah banyak ekspor dan impor beras Indonesia paling kecil dalam kurun waktu 2014 hingga 2017? Pada tahun berapakah banyak ekspor beras Indonesia paling besar dalam kurun waktu 2014 hingga 2017? Informasi lain apa sajakah yang dapat kamu peroleh dari penyajian tabel mengenai data ekspor-impor beras Indonesia tersebut?

Figure 3. Utilizing Contexts in The Textbook.

In the book's 'activity' (interactivity), which was the application of bridging with vertical instruments, students' construction and production, and intertwining, the students were provided more than one context and then asked to look for relationships or patterns between contexts to move into more general conclusions (see Figure 4). The use or modification of these general ideas or strategies in problem solving was also facilitated by the book through sub-chapter exercises or chapter evaluations. Thus, the principles of the RME approach developed in the textbook had facilitated students' mathematical generalization skills through its indicators.


3) Lempar atau undi kepingan uang logam dan dadu tersebut minimal 30 kali, kemudian catatlah permukaan sebelah atas (yang muncul) pada tabel seperti di bawah ini.

Percobaan (eksperimen)	Kejadian Muncul	Banyak Kejadian	Banyak Percobaan	$\frac{\text{Banyak kejadian}}{\text{Banyak Percobaan}}$
Pelemparan sekeping uang logam	Sisi Angka			
	Sisi Gambar			
Pelemparan dua keping uang logam	Sisi Angka dan Angka			
	Sisi Gambar dan Angka			
	Sisi Angka dan Gambar			
	Sisi Gambar dan Gambar			

4) Amatilah tabel pada langkah 3).
a) Kesamaan apakah yang dapat kamu temukan dari hubungan banyak kejadian dan banyak percobaan?
Jawab : ....
b) Dapatkah kamu menuliskan pola dari kesamaan yang kamu temukan?
Jawab : ....
c) Apakah yang dapat kamu simpulkan dari hubungan banyak kejadian dan banyak percobaan?
Jawab : ....

Dari **Kegiatan 5.2**, apakah yang dapat kamu simpulkan? Apakah kesimpulanmu sama dengan kesimpulan berikut?

Figure 4. Textbooks Activities.

The textbook with RME approach proved effective to improve mathematical generalization skills, supported by Veloo et al., (2015) and Dani et al., (2017) which concludd that RME was better than the conventional approach in terms of students' mathematical generalization skills. Similar research results also confirmed that one of the RME principles, namely bridging with vertical instruments that was closely related to mathematical modeling, had an effect on students' mathematical generalization reasoning skill (Suryani, 2016).

IV. CONCLUSION

The mathematics textbook for junior high school students in grade VIII even semester developed from the principles of the RME approach was effective in terms of mathematical generalization ability with a percentage of 93.33%, greater than the lower average score, 75% of students in the good category. The application of the five principles of the realistic mathematics approach in the textbook through the flow of activities providing more than one problem context, identifying similarities in patterns or strategies to draw conclusions related to the material and providing modeling exercises in this textbook, facilitated students' mathematical generalization skills. Thus, the developed textbook could be used in the learning process as an effort to foster students' mathematical generalization skills. In further development and research, it is expected that teachers or researchers could develop teaching materials with the RME approach oriented to the communicative skills and mathematical generalization skills at different educational levels or learning topics.

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