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Analysis of Number Material in Seventh-Grade Mathematics Teaching Materials Based on Praxeology

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Abstrak

Ketersediaan buku teks matematika yang tidak sesuai dapat mempengaruhi rendahnya kinerja akademik siswa. Penelitian ini bertujuan untuk menganalisis bahan ajar matematika sekolah dari perspektif praxeologis, di mana peneliti berusaha memahami bagaimana siswa berinteraksi dengan materi yang disajikan dalam bahan ajar, bagaimana mereka membuat keputusan tentang masalah mana yang akan diselesaikan, dan bagaimana desain serta konten buku teks mempengaruhi hasil belajar mereka. Ini adalah implementasi paradigma interpretatif dalam penelitian desain didaktik. (DDR). Melalui studi dokumen (dalam penelitian kualitatif yang dirancang secara fenomenologis) pada bahan ajar matematika sekolah Indonesia versi Kurikulum Merdeka, hasil yang diperoleh adalah: Komponen tugas (T) dalam materi tentang bilangan besar menggunakan teknik operasional; Komponen teknik (τ) sesuai karena informasi yang disampaikan dalam setiap pertemuan memiliki kontinuitas; Komponen teknologi (θ) belum sesuai, sehingga perbaikan dan peningkatan diperlukan dalam pengembangan media pembelajaran berbasis teknologi informasi dan komunikasi; dan Komponen teori (Θ) belum sepenuhnya selaras dengan teori konstruktivis, di mana siswa dapat membangun pengetahuan berdasarkan pengalaman masing-masing.
Kata Kunci: bahan ajar; matematika; materi bilangan; review praksiologi.

Abstract

The availability of mathematics textbooks that are not appropriate can influence students' low academic performance. This research aims to analyze school mathematics teaching materials from a praxeological perspective, where the researcher seeks to understand how students engage with the material presented in the teaching materials, how they make decisions about which problems to solve, and how the design and content of textbooks affect their learning outcomes. This implements the interpretive paradigm in didactical design research (DDR). This study will involve three principal stages in the data analysis procedure. Through document studies (in phenomenologically designed qualitative research) on the Indonesian school mathematics teaching materials version of the Merdeka Curriculum, the results obtained are: The task component (T) in the material on large numbers uses operational techniques; The technique component (τ) is appropriate because the information conveyed in each meeting has continuity; The technology component (θ) is not yet appropriate, so improvements and enhancements are needed in the development of information and communication technology-based learning media; and The theory component (Θ) is not yet fully aligned with constructivist theory, where students can build knowledge based on their respective experiences. The praxeological study of this teaching module provides a new perspective on how task design plays an important role in making the presentation of material more acceptable to students.
Keywords: teaching material; mathematics; topic of numbers; praxeology review.

I. INTRODUCTION

According to Hakim (2002), learning is a process of personality change that shows itself as a growth in knowledge, attitudes, habits, understanding, skills, thinking capacities, and other capabilities. Students don't always react favorably to the learning process as teachers intended. According to Liberna (2018), this frequently happens when students learn mathematics, even though it is a required topic at all educational levels. Mathematics is very necessary for students because it allows them to develop good information management skills to survive. Mathematics has become a mandatory subject at every level of formal education in Indonesia for several reasons, including: 1) Studying mahtematics helps us think more systematically (Yayuk et al., 2020); 2) Mathematics enhances logical thinking (Kenedi et al., 2019); 3) Mathematics trains our counting skills (Litkowski et al., 2020); and Mathematics develops the ability to draw deductive conclusions (Makowski, 2020).

However, the reality is that the quality of mathematics education is still low. Low mathematical ability is indicated by the PISA 2022 results released by the OECD (Organization for Economic Cooperation and Development, 2023), which show that the average mathematics score of Indonesian students reached 379, compared to the OECD average score of 487. Meanwhile, as reported by Mullis, Martin, Foy, and Hooper (2020) for the TIMSS 2019 survey results, no Indonesian students were found to have participated in the survey. It cannot be denied that the quality of mathematics education in Indonesia is still unsatisfactory.

A number of variables causes students' poor performance in mathematics. Students' poor performance in mathematics suggests that they have learning challenges (Pantaleon, Tamur, & Men, 2024). There are a number of internal and environmental factors that can contribute to kids' difficulties understanding mathematics (Sari, Supriadi, & Putra, 2022; Saepuloh, Luritawaty, & Afriansyah, 2024). A lack of enthusiasm in learning mathematics, bad study habits, and past academic setbacks are examples of internal causes (Kartina & Afriansyah, 2024). However, external influences include teachers' fast-paced instruction, overly dense content, and a lack of appropriate textbooks (Nursyifa et al., 2020; Ramda, 2017; Setiawan, 2019; Nurhasanah, Syafari, & Nurfaidah, 2022; Suwanto et al., 2023). As supplementary resources for subject study, teaching materials are essential for helping students comprehend and become proficient in the material. Teaching materials are methodically created using explanations and material unique to particular academic disciplines. In order to help students comprehend the learning contents, textbooks are chosen through a selection process that takes into account learning objectives, learning orientation, and students' developmental stages (Ramda, 2017; Setiawan, 2019; Safitra et al., 2023). In the learning process, textbooks are a crucial tool for influencing students' thinking, creativity, expression, and sense of freedom as well as their attitudes, interests, and reasoning (Dewi, 2022;

Halitopo, 2020). The way a topic is presented in textbooks is essential, as it shapes the pedagogical approach and provides opportunities for student learning. A topic omitted from a textbook is less likely to be addressed in classroom discussions (Veldhuis & van den Heuvel-Panhuizen, 2020). As a result, the textbooks that are used should be well-qualified. Students' learning outcomes in mathematics are positively impacted by a quality mathematics textbook. Textbooks should be thoroughly examined before being used in the classroom. This is done in order to find any discrepancies or errors. This is done in order to spot any discrepancies or errors in the book and take the necessary action to fix them right away. Four criteria pertaining to competency, content, strategy, and assessment are used to analyze the student textbooks for the 2013 curriculum (Tusyana & Luciana, 2019; Yenni, 2016; Pusporini et al., 2023).

Various textbooks are used in schools to support learning, including those published by private and governmental institutions. In this study, the textbook examined is the teaching material used by seventh-grade mathematics teachers. The teaching materials of the Merdeka curriculum were chosen to be analyzed using the concept of praxeology. The two blocks of praxis (the practical block) and logos (the theoretical block) comprise praxeology, which is a key element of the Didactic Anthropology Theory (Chevallard, 2006) (Khasanah et al., 2021; Z. H. Putra et al., 2020). Task (T) and technique (τ) are the two halves of the praxis block. Technology (θ) and theory (Θ) are the two parts of the logos block. T stands for the task type, τ for the method of solving the task, θ for the technology, which may also include knowledge for evaluating methods or taking discourse into account, and Θ for the theory that supports or evaluates the technology (Putra, 2019).

The material in this research is about numbers and focuses on introducing the concept of numbers. Numbers are an abstraction that allows us to extend the concept of simpler numbers, such as integers or rational numbers, into more complex concepts, such as complex numbers or real numbers. (Gauss, 1801). Understanding numbers is very important for students because numbers are a fundamental concept in mathematics and are essential in everyday life. Several previous studies focusing on the investigation and analysis of textbooks have been conducted, such as Putra (2020) who researched rational numbers using the anthropological theory of the didactic (ATD) approach based on praxiology, and Nisa (2023) who analyzed comparative material using praxiology.

Based on the background above, this study employs the interpretive paradigm in Didactical Design Research (DDR) with the goal of examining how number-related content is presented in textbooks, concentrating on the praxis and logos blocks, and determining the learning obstacles faced by students. It is anticipated that the results of this study will also help in the creation of future instructional materials.

II. METHOD

This research is conducted to answer the research question on students' learning barriers through the theory of praxeology. Qualitative research is chosen as an alternative approach in this study. The research process involves emerging questions and procedures, data is typically collected in participant settings, data analysis is done inductively building from specific themes to general themes, and the researcher creates interpretations of the meaning of the data (Creswell, 2014). The design used is phenomenology. According to Alase (2017), phenomenology is a qualitative research approach that allows researchers to use and apply their experiences and subjective relationships in the research exploration process. Thus, the phenomena observed in this study are the phenomena underlying the process of designing instructional materials, particularly phenomena related to reflection and evaluation of the design of teaching materials in the topic of numbers.

Qualitative research is flexible in nature. It is multiparadigmatic, with researchers working from different worldviews (such as post-positivism, interpretivism, and critical orientation), making it a highly diverse field of inquiry, and qualitative researchers are engaged in the research project (The Oxford Handbook of Qualitative Research Edited by Patricia Leavy: 2014). Thus, the researcher acts as the key instrument and has full control over the entire research process. Additionally, the researcher also utilizes documents as supporting instruments. The documents used in this study are the teaching material used by seventh-grade mathematics teachersmfor of the Merdeka Curriculum for Junior High School (SMP/Mts). The analyzed material is numbers, which is the first topic in the textbook for the odd semester, consisting of three subtopics: number concepts, properties of numbers, and number operations. In this study, these sections are limited to analyzing their presentation in the subtopics "number concepts" and "introduction to number operations."

In line with the research objectives, data was collected through document analysis. Document analysis, as a case-based investigative process focusing on written materials, notes, or documents, is commonly used in educational studies when textbooks or curricula serve as the data source. The documents in this study are the teaching material for Grade VII of the Merdeka Curriculum for Junior High School (SMP/MTs), and the design tasks within these documents are analyzed along with relevant conceptual frameworks.

Data collecting and results writing are two aspects of qualitative research development that are carried out in tandem with data analysis (Creswell, 2015). There will be three primary steps in the data analysis process for this study. The initial step involves selecting design units at random from the selected textbook. A praxeological table is used to record topics pertaining to the design activities. The researcher codes the test designs on their own in the second step. Experts in measurement and assessment verify the code creation's dependability in the third stage. The researcher uses reconvergence at this point to find discrepancies in the taxonomy table. The procedure then proceeds in a cyclical manner from this

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third step. Then, the design tasks that show inconsistency in coding by the researchers are discussed until reaching an agreement.

III. RESULT AND DISCUSSION

There are two parts of the analysis presented, namely the praxis block and the logos block, which are part of the implementation of praxeology theory. Before discussing the differences between the praxis block and logos, the researcher first discusses the introduction to the textbook. The introductory visualization in the book is expected to help students understand many terms for 'numbers' in everyday life. In the teaching materials, there is generally an inadequate visual introduction. In the teaching materials, it is mentioned that the numbers to the left of zero are negative integers and the numbers to the right of zero are called positive integers. This can trigger didactic challenges in understanding the concept of zero on the number line.

A. Practical Block Analysis

Tasks in the practice block are grouped into types of tasks found in the teaching materials. In the textbook, there are different T numbers, starting from T1, T2, ..., Tn. The concept of numbers in the practical block of the independent curriculum is presented through six types of tasks (T1, T2, ..., T6). The six types of tasks in the independent curriculum book are generally divided into three categories: understanding the definition of numbers using a number line (T1, T2), in-depth understanding of arithmetic operations on numbers (T3, T4, T5), and applying arithmetic operations on numbers in solving everyday problems (T6).

Technique (τ) in the practice block refers to the method used to complete a specific type of task (T). To identify techniques for each type of task, it begins with examining the solutions and approaches needed to solve the questions in each type of task, then creating categories that describe those solutions and approaches. In this study, the types of techniques used are based on the findings of Takeuchi and Shinno (2020), which consist of four types of techniques: perceptual (τ1), physical (τ2), operational (τ3), and algebraic (τ4). Technique τ1 involves task completion using visual assessment based on the presented form display. Technique τ2 involves task completion using physical aids such as rulers, compasses, or other tools. Technique τ3 involves task completion through investigation or discovery by students, aimed at developing their understanding. Meanwhile, technique τ4 involves task completion using mathematical expresions.

Task Types (T)	Techniques (τ)	Description of Each Technique
T_1 = If R, S, T, and U are negative integers, with R consisting of 3 digits, S consisting of 4 digits, T consisting of 5 digits, and U consisting of 6 digits, then the largest number is ...	τ_2, τ_3	Utilizing instruments to do activities that use prior perceptual processes (memory) to infer and determine the location of points on a number line.
T_2 = Arrange the following numbers from smallest to largest: a. -2, -12, 0, 29, 18, -34 b. 2.526, -3.526, 4.526, -5.526, 1.526	τ_3, τ_4	Utilizing earlier perceptual and memory processes (apriori) to infer the arrangement of numbers through mathematical expressions and actions involving number identification.
T_3 = The result of the arithmetic operation for the following numbers is: a. 283 – 198 + 17 = ... b. (3,14 × 213) - (3,14 × 13) = ... c. 501 x (-3) = ...	τ_3	Use prior perceptual processes (memory) to make inferences about the outcomes of mathematical procedures.
T_4 = In the mathematics competition, each correct answer is given a score of 4, each incorrect answer is given a score of -1, and if no answer is given, a score of 0 is assigned. Out of 40 questions given, Willy answered 30 questions, scoring 90. The number of questions Willy answered correctly is...	τ_3	Using past perceptual processes (memory) to make appropriate inferences about the outcomes of arithmetic operations.
T_5 = Please fill in the blanks with the appropriate numbers to make the following statement true. a. 500 : ..... = -4 b. (-270) : .... = 18	τ_3	Using earlier perceptual processes (apriori) to make appropriate inferences about the outcomes of mathematical operations.
T_6 = A gas balloon is tethered 300 meters above sea level on top of a building. A 30-story building is constructed on land 105 meters above sea level. A child is in the building on the 20th floor. If the child, the building, and the balloon are in a vertical line, and each floor height of the room is 4 meters, determine: a. the distance of the gas balloon from the top of the building. b. the child's position is measured from above sea level.	τ_2, τ_3	Using tools to do actions that infer and locate points on a number line based on prior memory-based perceptual processes.

Figure 1. Praxis Block of the Teaching Material.

Overall, in the practice block of the Merdeka Curriculum teaching materials, tasks from T_1 to T_6 are dominated by the use of technique τ_3. This shows that the task design in the Merdeka Curriculum introduces the concept of numbers by involving a lot of verification, namely the observation and development of students' knowledge that they have previously acquired, to form new knowledge. These tasks are designed to dominate the actions of observation and verification of knowledge through contextual examples. However, due to the excessive focus on observation, the opportunity to build knowledge through the observation process becomes limited, which ultimately results in a lack of learning opportunities for students. According to Hidayah and Forgasz (2020), textbooks often assign students tasks without providing clear instructions for completing them. On the other hand, the subject matter and tasks in the textbooks are explained quickly, but new ways to explore them are mostly absent.

T_1, T_2, and T_3 in the teaching materials used by the teacher have the same τ,

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namely τ_3, to construct the theory (definition of numbers), which is then refined using T_4, namely τ_2. However, the task design of T1, T2, T3, and T4, only emphasizes understanding the correct results of arithmetic operations on numbers. On the other hand, not all students can achieve the expected formulation using the understanding formed by T_1, T_2, T_3, and T_4. Due to different levels of intelligence (Guez et al., 2018), some students may not be able to draw the correct conclusions. This shows that T_1 to T_4 do not allow students to use and develop perception, memory, and introspection skills as they create new knowledge. Thus, overall, the techniques that have been developed have not yet created a structured learning path. The characteristics of justification τ_3 in T_1, T_2, and T_3 do not consider the diversity of knowledge, learning experiences, thinking styles, and students' learning potential. Furthermore, there is no valid verification of the new knowledge acquired by the students as a correct basis to support their findings.

T_5 and T_6 in the teacher's instructional materials refer to students' ability to identify a number so that they can independently recognize the arithmetic operations of integers present in the story, as well as understand the properties of the arithmetic operations of integers within that story. The goal is for students to present it in the form of a mathematical model built on previous experiences and knowledge. τ_3 is not involved in T_5, which consists of questions based on previously acquired knowledge, and is followed by τ_3 in T_6, where students determine the correct result through their ability to understand the correlation between the given terms and mathematical operations and to model word problems accurately and correctly. The design of task T_5 is not yet relevant to the expected formulation. However, in T_6, it is already relevant to the expected formulation, where τ_3 is used appropriately and interrelated to build students' understanding of the theory.

B. Logos Block Analysis

The two primary elements of the logos block are theory (Θ) and technology (θ). While theory (Θ) is the conclusion in the form of theoretical knowledge that serves to generalize the entire process of T, θ, and Θ, technology (θ) is the instrument or method utilized to justify a (τ).

Theme	Number of T	Technique (τ)	Technology (θ)	Theory (Θ)
Definition of fraction sequence	T_1	τ_2 = physical τ_5 = operational	θ_1 = The definition of numbers is the arrangement of well-ordered numbers.	Θ_1 = The arrangement of numbers according to their size or value is known as the order of numbers. Depending on the situation and need, numbers might be arranged from smallest to largest or the other way around.
	T_2	τ_5 = operational τ_4 = algebra		
Arithmetic operations of numbers	T_3 T_5	τ_5 = operational τ_3 = operational	θ_2 = For every mathematical operation, the final result varies depending on the number.	Θ_2 = Arithmetic operations are a sequence of steps or mathematical processes that are applied to numbers in order to get a new outcome. In mathematics, addition, subtraction, multiplication, and division are the four fundamental arithmetic operations.
Properties of numbers	T_6	τ_2 = physical τ_3 = operational	θ_3 = To make numbers easier to understand, use the number line.	Θ_3 = Commutative, distributive, associative, and identity properties are some of the common characteristics of numbers.

Figure 2. Logos Block of the Teaching Material.

The book's first three task types (T_1, T_2, and T_3) are designed to improve comprehension of the notion of numbers using θ_1 (the definition of numbers is the well-ordered position of digits). Since the solution of these tasks relies on mental operations to link perceptual processes and create learned knowledge, θ_1 supports τ_3. T_4 validates T_1, T_2, and T_3 through τ_2, which is supported by θ_1. All things considered, the teaching material T_1, T_2, T_3, and T_4 task categories yield θ_1 (numbers are a mathematical notion used to express or quantify quantity or amount). Although they are similar, the final two task types (T_5 and T_6) produce different θ. θ_2 (arithmetic operations) is obtained from T_5.

The training materials primarily employ operational strategies along with contextual problems to solve assignments. Children can feel more connected when objects are shown through activities they are familiar with (Hong & Choi, 2018). According to Sianturi et al. (2021), the textbook simply offers basic settings that may be beneficial and essential, but they are regarded as demanding and do not require moderate or high levels of cognitive mastery. When students come across mathematical issues that call for higher cognitive capacities, this can lead to

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epistemological hurdles (Fuadiah et al., 2019).

The teaching materials for Θ_2 and Θ_3 do not attempt to construct new knowledge; instead, they rely entirely on perceptual abilities by repeating previously presented sights. According to the theory of didactic situations, situational actions are always the first step in the learning process because they give students the opportunity to apply their knowledge and experiences, develop their perceptions of the environment and the actions that take place within it, and help them process information and come to new understandings. Students are prevented from finishing assignments that are more difficult or distinct from the examples provided by the book's dearth of learning opportunities. This supports Tumay's (2016) assertion that mistakes in material delivery frequently lead to misconceptions in information acquisition, which in turn causes learning issues. It is strongly advised to create more diverse assignments so that students can apply a range of cognitive abilities and develop their knowledge in a more comprehensive way.

IV. CONCLUSION

The Merdeka Curriculum teaching materials used by teachers in number subjects have a task component (T) that heavily utilizes operational techniques. The mathematics teaching materials version of the Merdeka Curriculum, the results obtained are: (1) The task component (T) in the material on large numbers uses operational techniques; (2) The technique component (τ) is appropriate because the information conveyed in each meeting has continuity; (3) The technology component (θ) is not yet appropriate, so improvements and enhancements are needed in the development of information and communication technology-based learning media; and (4) The theory component (Θ) is not yet fully aligned with constructivist theory, where students can build knowledge based on their respective experiences. Although studying mathematics topics is quite difficult, the praxeological study of this teaching module provides a new perspective on how task design plays an important role in making the presentation of material more acceptable to students.

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