Context-based tasks in mathematics textbooks for vocational high school students

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Abstract. This study analyzes the context-based tasks in mathematics textbooks for grade ten and eleven vocational high school students in Indonesia. A vertical analysis was done based on the types of context, types of information, and cognitive demand types. This study is a descriptive qualitative study involving an external coder to ensure its validity and reliability. The data collection was conducted through text analysis and literature study. Whereas the data analysis used is content analysis. Based on the data analysis, it can be concluded that there are still little tasks with the relevant and essential context in the mathematics textbooks (10% for grade ten and 30% for grade eleven). Regarding vocational high school expertise, the tasks are relevant to vocational high school’s specific expertise. Regarding the types of information, tasks with matching categorized are dominant: 54% in grade ten and 88% in grade eleven. For the types of cognitive demand, grade ten is dominated with reproduction (54%), and grade eleven is dominated with connection (46%). Cohen’s Kappa coefficient on the types of context, types of information, and cognitive demand types in both mathematics books for vocational high school students grades ten and eleven are in a good or excellent category.

1. Introduction
Mathematics is one of the sciences that underlies the development of science and technology in the modern era. Learning mathematics will make students have the ability to think logically, analytically, systematically, and creatively. Besides that, the ability to solve mathematics problems that lie in that real-world context should be a core education objective. Today and in the future, every country needs citizens mathematically to deal with the complex everyday surroundings and rapidly changing professional environments [1], [2].

Textbooks are one of the teaching materials that can be used to assist teachers in delivering learning materials. In learning mathematics, books are a potential learning resource that can help students learn independently. Mathematics textbooks are one such opportunity from which students can learn how to solve particular problems [3], [4].

At the vocational high school level, mathematics textbooks are beneficial for students in understanding mathematical concepts [5]. Charalambous et al. [6] state that there are several similarities and differences in textbook findings regarding the topics and their order. Therefore, analysis is needed to understand the similarities and differences in the content of textbooks, especially on the suitability of
the context of the book’s questions with the fields of expertise in vocational high schools. This study needs to be done because there are nine areas of expertise in vocational high schools: technology and engineering, energy and mining, information and communication technology, health and social work, agribusiness and agrotechnology, maritime, business and management, tourism, arts and creative industries [7], each of which has characteristics. Therefore, the context in the mathematics textbook must be connected to each of these areas of expertise.

As mentioned by Wijaya et al. [8], horizontal analysis is an analysis that examines general characteristics such as physical characteristics and instructional components. These characteristics include page size, page count, and page area. Instructional features include problems, sample sections, assignments/exercises, and competency tests. Then, vertical analysis analyzes how the textbook is presented and how it contains a context. Then they are grouped into three categories, namely types of context (no context, camouflage context, relevant and essential context), types of information (matching, missing, and superfluous), and types of cognitive demand (connection, reproduction, and reflection).

The scarcity of research examining the characteristics of mathematics textbooks for vocational high schools is motivated to conduct this research. Specifically, this study analyzes the vocational high school mathematics textbooks’ factors based on the vertical analysis.

2. Methods
This study is a qualitative descriptive study on mathematics textbooks for vocational high school students in Indonesia. As mentioned by Sugiyono [9], in qualitative research, the instruments are the researchers themselves. Moreover, an external coder is involved in this study ensures the validity and reliability of the data. The data collection was conducted through text analysis and literature study. The framework analysis used in this study is vertical analysis, as mentioned by Charalambous et al. [6], which consists of types of context, types of information, dan types of cognitive demand. Table 1 describes the analysis framework for textbook analysis based on vertical analysis [8].

| Task Characteristic | Sub-category | Explanation |
|---------------------|--------------|-------------|
| Types of context    | No Context   | - Refers only to mathematical objects, symbols, or structures. |
|                     | Camouflage   | - Experiences from everyday life or common-sense reasoning are not needed. |
|                     | Context      | - The mathematical operations needed to solve the problems are already noticeable. |
|                     | Relevant      | - The solution can be found by combining all numbers given in the text. |
|                     | Essential     | | |
| Types of information| Matching     | - The tasks contain precisely the information needed to find the solution. |
|                     | Missing       | - The tasks contain less information than needed, so students need to derive additional data. |
|                     | Superfluous   | - The tasks contain more information than needed, so students need to select information. |
| Types of cognitive  | Connection    | - Reproducing representations, definitions or facts |
| demand              |              | - Interpreting simple and familiar representations |
- Memorization or performing explicit routine computations/procedure

Reproduction - Integrating and connecting across content, situations, or representations
- Non-routine problem solving
- Interpretation of problem situations and mathematical statements
- Engaging in simple mathematical reasoning

Reflection - Reflecting on and gaining insight into mathematics
- Constructing original mathematical approaches
- Communicating complex arguments and complex reasoning
- Making generalizations

Whereas the data analysis used is content analysis. The content analysis was carried out by coding by the researcher. Furthermore, the coding reliability is checked by an external coder who performs the coding on the two chapters of the mathematics books for grade ten and two chapters of the mathematics books for grade eleven, because of an external coder codes research results in about 15% of the total question [8]. Furthermore, the researchers coding results and the external coder were obtained Cohen's Kappa coefficient on each aspect of the type of context, type of information, and type of cognitive demand. Table 2 shows the interpretation of the Kappa coefficient [10].

**Table 2. The Interpretation Kappa Coefficient**

| Kappa Coefficient | Degree of Agreement |
|--------------------|---------------------|
| < 0.40             | Poor                |
| 0.40 – 0.60        | Fair                |
| 0.61 – 0.75        | Good                |
| > 0.75             | Excellent           |

3. Results and Discussion

This study focuses on analyzing mathematics textbooks for grade ten and grade eleven of vocational high school students. The mathematics textbook for grade ten consists of four chapters: equations and inequalities of linear absolute values with one-variable, linear equations with three-variables, functions, and trigonometry. Whereas, the mathematics textbook for grade eleven consists of eight chapters: mathematical induction, linear programming, matrices, transformation, program linear, limit function, sequences, derivative, and integral.

The analysis was started by categorizing the tasks provided in the two books based on context types. Afterward, the tasks indexed in relevant and essential context are then categorized based on the types of information and cognitive demand types. An external coder coded two chapters of the mathematics books for grade ten and two chapters of the mathematics books for grade eleven. Lastly, the researchers' coding results and the external coder were obtained from Cohen's Kappa coefficient. This section describes the analysis of each aspect of the types of context, types of information, and cognitive demand types.

3.1. Types of Context

Based on the types of context, the mathematics textbooks for both grade ten and grade eleven of vocational high school students are dominated by tasks with no context category. This finding is similar to previous studies conducted in lower secondary school mathematics textbooks, where no context category is also dominant [11], [8]. In contrast, providing relevant and essential context is essential to
stimulate and enhance students’ mathematics literacy [8], [12]–[14]. Table 3 shows the detailed results of the analysis based on the types of context.

**Table 3.** The Analysis Based on the Types of Context

| Type of Context                     | Grade Ten | Grade Eleven |
|------------------------------------|-----------|--------------|
| No Context                         | 73%       | 56%          |
| Camouflage Context                 | 17%       | 14%          |
| Relevant and Essential Context     | 10%       | 30%          |

As mentioned by Wijaya et al. [8], no context category refers to tasks that only provide mathematical objects, symbols, or structures. Figure 1 shows an example of tasks with no context category. The task is about the equation of linear absolute value with one-variable learned by grade ten vocational high school students [15]. Therefore, regarding the vocational high school’s expertise mentioned in [7], this task does not relate to any expertises.

Figure 1. An Example of Tasks with No Context Category

Maria’s mathematics scores in mathematics are 79, 67, 83, and 90. If she has to take an exam once more and expect to have an average score of 81. How much score which she has to receive so that the average value lowest deviate 2 points.

Figure 2 shows an example of a task with the camouflage category. Although the task provides an everyday life situation, the solution can be found by combining all numbers given in the text [8]. The task is related to the central tendency, which is a part of statistics learned by vocational high students in grade eleven [16]. Therefore, regarding the vocational high school’s expertise mentioned in [7], this task does not relate to any expertises.

Figure 2. An Example of Tasks with Camouflage Context Category
Based on the analysis of the types of context, the Kappa coefficient is 0.734 for the grade ten mathematics textbook and 0.653 for the grade eleven mathematics textbook. Therefore, it can be concluded that the degree of agreement between the researcher and the external coder is good and excellent, respectively [10]. The examples of tasks with relevant and essential context will be described in the analysis based on types of information and types of cognitive demand.

3.2. Types of Information
The mathematics textbooks for both grade ten and grade eleven of vocational high school students are dominated by tasks with matching categories based on the types of information. This finding is similar to previous studies conducted in lower secondary school mathematics textbooks, where the matching category is also dominant [8]. The tasks with missing and superfluous types are still limited, whereas tasks with those categories enhance students’ creativity and deepen students’ understanding [17], [18].

Table 4 shows the detailed results of the analysis based on the types of information.

|                  | Grade Ten | Grade Eleven |
|------------------|-----------|--------------|
| Matching         | 54%       | 88%          |
| Missing          | 46%       | 11%          |
| Superfluous      | 0%        | 1%           |

Figure 3 shows an example of a task with the relevant and essential context category. Regarding the types of information, the task is in the missing category. It is because the tasks contain less information than needed, so students need to derive additional data [8]. The task is related to the number sequence, which is learned by vocational high students in grade eleven [16]. Regarding the vocational high school’s expertise mentioned in [7], this task does not relate to any expertises. However, it is a common everyday life situation which is suitable for vocational students with all expertises.

Look at the piles of oranges. How to predict the number of oranges for each pile.

Figure 3. An Example of Tasks with Missing Category

Based on the analysis of the types of information, the Kappa coefficient is 1 for grade ten and grade eleven mathematics textbooks. Therefore, it can be concluded that the degree of agreement between the researcher and the external coder is excellent [10].

3.3. Types of Cognitive Demand
Based on the types of cognitive demand, the vocational high school students’ mathematics textbooks for grade ten are dominated by tasks with the reproduction category. The connection category dominates that of grade eleven. This finding is partially similar to previous studies conducted in lower secondary school mathematics textbooks, where the reproduction category is dominant in all books analyzed [8]. Table 5 shows the detailed results of the analysis based on the types of information.
Table 5. The Analysis Based on the Types of Cognitive Demand

| Category   | Grade Ten | Grade Eleven |
|------------|-----------|--------------|
| Connection | 32%       | 46%          |
| Reproduction | 54%   | 12%          |
| Reflection | 14%       | 42%          |

In terms of the types of cognitive demand, the connection category means: reproducing representations, definitions or facts, interpreting familiar and straightforward expressions, and memorization or performing exact routine computations/procedure [8]. It is the lowest level of the types of cognitive demand. Figure 4 shows an example of a task with the connection category. The task is related to the equations and inequalities of linear absolute values with one-variable, which vocational high students learn in grade ten [15]. Regarding the vocational high school’s expertise mentioned in [7], this task relates to health and social work expertise. Therefore, this task is suitable for learning mathematics in vocational high school students with health and social work expertise.

Translation

A baby was born prematurely in a mother and child hospital. To regulate the baby’s body temperature to remain stable at 34°C, it must be put in an incubator for two days. The incubator temperature should be maintained in the range of 32°C to 35°C.

The baby was born weighing 2100-2500 grams. If the effect of room temperature causes the incubator temperature to deviate by 0.2°C, determine the interval for changing the incubator temperature.

Figure 4. An Example of Tasks with Connection Category

Whereas Figure 5 shows an example of a task with the connection category in mathematics textbooks for grade eleven. The task is related to the number sequence learned by vocational high students in grade eleven [16]. Regarding the vocational high school’s expertise mentioned in [7], this task relates to business and management. Therefore, this task is relevant to be used as a problem in learning mathematics for vocational high school students with business and management expertise.
Lani, a batik craftsman in Gurung Kidul. She can finish six pieces of batik cloth measuring 2.4 x 1.5 m in one month. The demand for batik cloth continues to increase so that Lani has to provide nine pieces of batik cloth in the second month, and 12 pieces in the third month. She expected that the number of batik cloth for the following month would be three more than the previous month. With this work pattern, in what month did she finish 63 pieces of batik cloth.

Based on the analysis of the types of cognitive demand, the Kappa coefficient is 0.687 for the grade ten mathematics textbook and 1 for the grade eleven mathematics textbook. Therefore, it can be concluded that the degree of agreement between the researcher and the external coder are good dan excellent, respectively [10].

4. Conclusion
There are still few tasks with the relevant and essential context in the mathematics textbooks for grade ten (10%) and in the mathematics textbooks for grade eleven (30%). Some of the tasks are everyday tasks relevant to all vocational high school’s expertise. At the same time, some tasks are appropriate for the specific expertise of vocational high school. Regarding the types of information, tasks with matching categorized are dominant: 54% in grade ten and 88% in grade eleven. For the kinds of cognitive demand, grade ten is dominated with reproduction (54%), and grade eleven is dominated with connection (46%). Cohen’s Kappa coefficient on the types of context, types of information, and cognitive demand types in the analysis of both mathematics books for vocational high school students grades ten and eleven are in a good or excellent category.

References
[1] N. OECD, “The PISA 2003 assessment framework: Mathematics, reading, science and problem solving knowledge and skills,” OECD Paris, 2003.
[2] OECD, “PISA 2018 Results,” 2018. [Online]. Available: https://www.oecd.org/pisa/Combined_Executive_Summaries_PISA_2018.pdf.
[3] T. P. Mkhatshwa and H. M. Doerr, “Opportunity to learn solving context-based tasks provided by business calculus textbooks: An exploratory study,” no. November, 2015, doi: 10.1016/j.jhep.2016.06.027.
[4] L. Jukić Matić and D. Glasnović Gracin, “The use of the textbook as an artefact in the classroom A case study in the light of a socio-didactical tetrahedron Das Schulbuch als Artefakt in der Klasse,” Journal für Mathematik-Didaktik, vol. 37. pp. 349–374, 2016, doi: 10.1007/s13138-016-0091-7.
[5] A. S. Asmara, H. Hardi, and Y. Ardiyanti, “Contextual Learning on Mathematical Subjects to Enhance Student Motivation for Learning in Vocational High School,” JPI (Jurnal Pendidik. Indones., vol. 8, no. 2, p. 228, 2019, doi: 10.23887/jpi-undiks.v8i2.13499.
[6] C. Y. Charalambous, S. Delaney, H. Y. Hsu, and V. Mesa, “A comparative analysis of the addition and subtraction of fractions in textbooks from three Countries,” Math. Think. Learn.,
vol. 12, no. 2, pp. 117–151, 2010, doi: 10.1080/10986060903460070.

[7] Kementerian Pendidikan dan Kebudayaan, “Spektrum_Perdirjen_06_2018.Pdf.” 2018.

[8] A. Wijaya, M. van den Heuvel-Panhuizen, and M. Doorman, “Opportunity-to-learn context-based tasks provided by mathematics textbooks,” Educ. Stud. Math., vol. 89, no. 1, pp. 41–65, 2015, doi: 10.1007/s10649-015-9595-1.

[9] Sugiyono, Metode Penelitian Kuantitatif, Kualitatif, dan R&D. Bandung: Alfabeta, 2013.

[10] J. L. Fleiss, B. Levin, and M. C. Paik, “The measurement of interrater agreement,” in Statistical methods for rates and proportions, 1981, pp. 212–236.

[11] Budi Murtiyasa, Sri Rejeki, and Sarlita Murdaningsih, “An Analysis of Problems on Eight Grade of Mathematics Textbook Based on Plsa’s Framework,” in 3rd International Conference on Research, Implementation, and Education of Mathematics and Science (3rd ICRIEMS), 2016, pp. 305–308.

[12] T. Laurens, F. A. Batlolona, J. R. Batlolona, and M. Leasa, “How does realistic mathematics education (RME) improve students’ mathematics cognitive achievement?,” Eurasia J. Math. Sci. Technol. Educ., vol. 14, no. 2, pp. 569–578, 2018, doi: 10.12973/ejmste/76959.

[13] S. Rejeki and R. I. I. Putri, “Models to support students’ understanding of measuring area of circles,” in Journal of Physics: Conference Series, 2018, vol. 948, no. 1, doi: 10.1088/1742-6596/948/1/012058.

[14] S. Rohman, Susanto, Hobri, Saiful, and Sahnawi, “An analysis of students’ literacy ability in mathematics teaching with realistic mathematics education based on lesson study for learning community,” J. Phys. Conf. Ser., vol. 1265, no. 1, 2019, doi: 10.1088/1742-6596/1265/1/012004.

[15] B. Sinaga et al., Matematika SMA/MA/SMK/MAK Kelas X, Edisi Revi. Jakarta: Kementrian Pendidikan dan Kebudayaan Republik Indonesia, 2017.

[16] S. Manullang et al., Matematika SMA/MA/SMK/MAK Kelas XI, Edisi Revi. Jakarta: Kementrian Pendidikan dan Kebudayaan Republik Indonesia, 2017.

[17] A. Wijaya, “How do open-ended problems promote mathematical creativity? A reflection of bare mathematics problem and contextual problem,” J. Phys. Conf. Ser., vol. 983, no. 1, 2018, doi: 10.1088/1742-6596/983/1/012114.

[18] H. L. Dewi and Marsigit, “Mathematical creative thinking and problem posing: An analysis of vocational high school students’ problem posing,” J. Phys. Conf. Ser., vol. 1097, no. 1, 2018, doi: 10.1088/1742-6596/1097/1/012134.