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STUDENTS' ERRORS IN SOLVING SOLID GEOMETRY PROBLEMS

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Abstract

Geometry is one branch of mathematics that is important for students to learn because it can develop problem-solving skills. However, there are still errors in solving problems related to geometry, one of which is the topic of a solid geometry. This study aims to conduct a literature review related to student errors in solving problems on the topic of solid geometry. The research method used is Systematic Literature Review (SLR). Data collection techniques were carried out by documenting and reviewing 43 nationally indexed articles obtained from Google Scholar, then grouped into several categories. 17 articles discuss students' errors on the topic of a solid geometry. Based on the results of the study, it was found that there were still errors in solving problems related to the solid geometry made by students, especially conceptual errors. This is due to a lack of understanding of the concept and the selection of an incorrect formula in solving the problem of solid geometry.

***Keywords**: Errors, solid geometry, systematic literature review (SLR).*

Abstrak

Geometri ialah salah satu cabang pelajaran matematika yang penting dipelajari oleh siswa sebab dapat mengembangkan keterampilan pemecahan masalah. Namun, masih terdapat kesalahan dalam menyelesaikan masalah terkait geometri salah satunya topik bangun ruang sisi datar. Penelitian ini bertujuan untuk melakukan kajian literatur terkait kesalahan siswa dalam menyelesaikan soal pada topik bangun ruang sisi datar. Metode penelitian yang digunakan adalah *Systematic Literature Review* (SLR). Teknik pengumpulan data dilakukan dengan mendokumentasi dan mereviu artikel terindeks nasional sebanyak 43 artikel yang diperoleh dari *Google Scholar*, kemudian dikelompokkan kedalam beberapa kategori. Terdapat 17 artikel yang membahas tentang kesalahan siswa pada topik bangun ruang sisi datar. Berdasarkan hasil penelitian, didapatkan bahwa masih terdapat kesalahan dalam menyelesaikan masalah terkait bangun ruang sisi datar yang dilakukan oleh siswa terutama kesalahan konsep. Hal tersebut dikarenakan kurangnya pemahaman konsep serta pemilihan rumus yang tidak tepat dalam menyelesaikan permasalahan bangun ruang sisi datar.

Kata kunci: Bangun ruang sisi datar; kesalahan; *systematic literature review* (SLR)

INTRODUCTION

Mathematics is a science that consists of abstract objects consisting of facts, concepts, operations, and principles (Isrok'atun & Rosmala, 2018). Mathematics is one of the sciences that is learned from elementary school to high school, even in college. At school, the mathematics learned is oriented towards achieving mathematics learning goals, one of which is developing problem solving skills

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(Ardianzah & Wijayanti, 2020). Mathematics learned in school is divided into five branches including arithmetic, algebra, geometry, calculus, and statistics and probability.

Starting from the lowest level of education, there are still some students who face difficulties in mastering certain materials or topics in mathematics lessons. Several things can cause difficulties in learning mathematics, including the low basic ability of students or lack of mastery of prerequisite material and differences in students' capacities in solving certain problems or tasks that allow errors to occur. These errors can be used as information to track students' learning difficulties in mathematics, so they can determine alternative solutions (Farida, 2015). This matter is meaningful for teachers to recognize the location of students' errors so that they can know and anticipate the difficulties they feel when learning mathematics.

Geometry material is one of the branches of mathematics that is important for students to learn because according to Walle (2001), some problems in everyday life are related to geometry, play an important role in pursuing other branches of mathematics, and can develop problem-solving abilities (Suwito, 2017). Geometry is an abstract concept so it cannot be transferred in the form of information only, but must be constructed based on the knowledge possessed by students. (Nurhasanah, Kusumah, & Sabandar, 2017). It is intended that students can pursue learning materials well and stored in students' long-term memory, not just memorizing formulas. One of the geometry materials studied in high school is the topic of solid geometry. This topic is important to learn because it is a prerequisite material for studying geometry topics that are studied in high school. However, several studies show that there are still student errors in solving problems in the solid geometry material. This makes researchers interested in conducting a literature review of the results of research related to errors in solving problems made by students on the topic of solid geometry.

METHOD

The method used in this research is systematic literature review (SLR) method which is used to identify, examine, research, and investigate certain relevant studies (Triandini, Jayanatha, Indrawan, Putra, & Iswara, 2019). The sample in this study used 17 articles. The 17 articles were choosen because of the explanations related to student errors on the topic of solid geometry. The articles were obtained from *Google Scholar* published in the period 2013 to 2022, with the keyword analysis of student errors.

The first step in this research is to collect articles that discuss the analysis of student errors in mathematics. Researchers obtained 43 articles, then grouped them by title, journal name, education level, year of publication, number of participants, learning materials, and journal methods. After grouping the articles, the following data were obtained in the category of learning materials.

Table 1. Grouping of articles based on learning material

No	Material	Number of Articles
1	Geometry	32
2	Calculus	1
3	Arithmatic	4
4	Algebra	5
5	Unknown	1
	Total	43

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Based on Table 1, articles related to geometry material were found as many as 32 articles. Of the 32 articles, 17 of them are articles related to the topic of solid geometry, 13 of which are articles related to the topic of quadrilateral, one article is related to the topic of the Pythagorean theorem, and one article is related to other topics namely points, lines, and angles. At first, the researcher collected articles related to the analysis of student errors in learning mathematics on various topics. However, after the articles were grouped, the researcher was interested in studying the topic of solid geometry because in the last 10 years this topic was still found errors and not only at the junior high school level but at other levels.

This study aims to obtain information related to students' errors in the solid geometry topics from previous studies. In addition, analyzing the articles that have been selected so that the types of errors that are often experienced by students can become conclusions, new ideas, and recommendation for further research.

RESULTS AND DISCUSSION

The results of the research data included in this literature review are a summary of research related to the solid geometry. The following research data are presented in table 2 (the title and journal name displayed in Indonesian).

Table 2. Research results related to student errors on the solid geometry

No.	Author's Name and Year of Publication	Title	Journal Name	Research Result
1	(Yan, Bistari, & Hamdani, 2013)	Analisis Kesalahan dalam Menyelesaikan Soal Luas Permukaan serta Volume Bangun Ruang Sisi Datar di SMP	Jurnal Pendidikan dan Pembelajaran Khatulistiwa	The results of the study showed that grade IX students made errors in working on questions about volume and surface area of solid geometry including conceptual errors, procedural errors, and calculation errors.
2	(Fiqri, Muhsetyo, & Qohar, 2016)	Studi Kasus Kesalahan Siswa dalam Menyelesaikan Soal Luas Permukaan dan Volume Bangun Ruang Sisi Datar di SMP	Prosiding Seminar Matematika dan Pendidikan Matematika	There were still errors found by class IX students in solving problems related to flat shapes, namely reading errors, understanding questions, transformation errors, skill errors, notation errors, and errors in calculations or carelessness. This is caused by lack of mastery of the material, lack of student readiness, and lack of understanding of the steps in problem solving.

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No.	Author's Name and Year of Publication	Title	Journal Name	Research Result
3	(Istiani & Hidayatulloh, 2017)	Analisis Kesalahan Siswa dalam Menyelesaikan Soal pada Materi Bangun Ruang Sisi Datar	Prosiding Seminar Nasional Matematika dan Pendidikan Matematika	There were four errors made by students, there are errors in receiving information, errors about concepts, errors in counting, and errors dealing with prerequisite material.
4	(Darmawan, Kharismawati, Hendriana, & Purwasih, 2018)	Analisis Kesalahan Siswa SMP Berdasarkan Newman dalam Menyelesaikan Soal Kemampuan Berpikir Kritis Matematis pada Materi Bangun Ruang Sisi Datar	Juring (Journal for Research in Mathematics Learning)	Errors made by students in solving story problems mathematical critical thinking skills in solid geometry consist of six aspects, there are reading problems, understanding problems, transforming process skills errors, writing answers errors, and carelessness errors.
5	(Lestari, Aripin, & Hendriana, 2018)	Identifikasi Kesalahan Siswa SMP dalam Menyelesaikan Soal Kemampuan Penalaran Matematik pada Materi Bangun Ruang Sisi Datar dengan Analisis Kesalahan Newman	Jurnal Pembelajaran Matematika Inovatif	The most common type of Newman error in solving mathematical reasoning problems is notational errors. In general, this is because students do not understand the concept, students are less precise in reading, understanding, and answering questions, as well as students who are not accustomed to dealing with problems of mathematical reasoning abilities.
6	(Kurniawati, 2018)	Analisis Kesalahan Matematika Ditinjau dari Kemandirian Belajar Siswa pada Materi Bangun Ruang Sisi Datar	Ekuivalen	In solving problems related to the shape of a solid geometry, the errors made by class VIII students are grouped based on high learning independence and low learning independence. At high learning independence, students make errors in principle and students are careless. Meanwhile, at low learning

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No.	Author's Name and Year of Publication	Title	Journal Name	Research Result
				independence, students use inaccurate formulas, notation errors in writing answers, calculation errors, and principle errors.
7	(Atiqoh, 2019)	Analisis Kesalahan Siswa dalam Menyelesaikan Soal Pemecahan Masalah pada Materi Pokok Bangun Ruang Sisi Datar	ALGORITMA Journal of Mathematics Education	There are five types of student errors found including conceptual errors, language interpretation errors, technical errors, errors in using data, and errors in making conclusions. In general, the causes of these errors are students' lack of understanding of the material, students' lack of thoroughness, lack of student skills, and unable to use geometric ideas in solving problems.
8	(Hidayat, 2019)	Analisis Kesalahan Konsep dan Kesalahan Prosedur dalam Menyelesaikan Soal Bangun Ruang Sisi Datar	Jurnal Equation	There are still errors in solving solid geometry questions made by students, including the location of conceptual errors where students are wrong in connecting two concepts and using inappropriate formulas, as well as procedural errors where students are not right in using data, wrong in using the data. perform calculation operations, and are less observant when working on the questions given.
9	(Hutajulu, Senjayawati, & Minarti, 2019)	Analisis Kesalahan Siswa SMK dalam Menyelesaikan Soal Kecakapan Matematis pada Materi Bangun Ruang	Musharafa: Jurnal Pendidikan Matematika	There are errors made including errors based on conceptual, procedural, and technical. In general, the cause of students making errors when solving mathematical skills problems is that students are not careful during the problem-solving process.

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No.	Author's Name and Year of Publication	Title	Journal Name	Research Result
10	(Ifasiroh, 2019)	Analisis Kesalahan Siswa SMP dalam Menyelesaikan Soal Materi Bangun Ruang Sisi Datar Ditinjau dari Kemampuan Spasial	Jurnal Simki	Students with high, medium, and low spatial abilities make errors in solving solid geometry problems. These errors include conceptual errors, where students do not use the correct way to solve problems; Data errors, where students do not use data from questions and students enter wrong data into the formulas written by students in solving problems; Data interpretation errors, where students do not understand the use of symbols to solve problems; and technical errors, where students cannot complete problem-solving procedures and students are correct in problem-solving steps but perform inaccurate calculations.
11	(Mazlan, Roza, & Maimunah, 2020)	Analisis Kesalahan Siswa SMP dalam Menyelesaikan Soal pada Materi Bangun Ruang Sisi Datar	Jurnal Kajian Teori dan Praktik Kependidikan	Errors were made by students in solving the problem of surface area and volume of plane shapes, namely conceptual errors, technical errors, and procedural errors. The type of error that most often occurs is a conceptual error.
12	(Prihatini & Setiawan, 2020)	Analisis Kesalahan Siswa SMP Kelas IX dalam Menyelesaikan Soal pada Materi Pokok Bangun Ruang Sisi Datar	MAJU: Jurnal Ilmiah Pendidikan Matematika	Errors made by students in solving the topic of solid geometry, including choosing a formula, theorem, or definition to answer questions; the use of formulas, theorems, or definitions that do not comply with the prerequisite conditions; no formulas, theorems or definitions are used; wrong when performing arithmetic

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				operations; wrong in writing; incorrectly see symbols, graphs and tables in the form of mathematical models; and less precise in writing conclusions.
13	(Yulianti & Novtiar, 2021)	Analisis Kesalahan Siswa dalam Menyelesaikan Soal *Higher Order Thinking Skills* (HOTS) Materi Bangun Ruang Sisi Datar	Jurnal Pembelajaran Matematika Inovatif	The results of the research show that the most common student errors found in solving HOTS-based questions on the solid geometry material were students' errors in solving the problem indicators for finding the surface area of cuboid and cube with the bloom creating (C6) in the taxonomy stage.
14	(Pratiwi & Anita, 2021)	Analisis Kesalahan Siswa dalam Menyelesaikan Soal Bangun Ruang Sisi Datar	Jurnal Pembelajaran Matematika Inovatif	Errors that often occur are confusion when solving problems because they do not understand the questions, are not careful when reading about and are not careful when calculating, and forget the formula. Some of the causes of these errors include students not mastering concepts, only memorizing existing formulas without knowing the formulas used so that they learn basic concepts, and lacking material prerequisites.
15	(Amni & Kartini, 2021)	Analisis Kesalahan Siswa dalam Menyelesaikan Soal Bangun Ruang Sisi Datar Bagian Balok Berdasarkan Teori Newman	Juring (Journal for Research in Mathematics Learning)	The most errors occurred in question number three and the types of errors from the five stages of Newman mostly occurred at the final stage namely encoding errors. At this stage, students do not answer the final answer or based on questions about the problem.

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No.	Author's Name and Year of Publication	Title	Journal Name	Research Result
16	(Wulandari, Kamid, & Haryanto, 2021)	Analisis Kesalahan Konstruksi Konsep pada Materi Bangun Ruang Sisi Datar Berdasarkan Pemberian Scaffolding	Aksioma Jurnal	The results of research related to concept construction, among others, are that students make errors on the "true" *Pseudo Construction* indicator and "wrong" *Pseudo Construction* indicator due to a lack of understanding of concept construction, while students who make errors on the *mis-logical construction* indicator are due to the students' lack of accuracy in performing arithmetic operations.
17	(Ulpa, Maharani, Marifah, & Ratnaningsih, 2021)	Analisis Kesalahan Siswa dalam Menyelesaikan Soal Kontekstual pada Bangun Ruang Sisi Datar Ditinjau dari Teori Nolting	Journal of Mathematics and Mathematics Education	There are six types of student errors in solving contextual problems based on Nolting's Theory, including reading instructions errors, carelessness errors, conceptual errors, application errors, test errors, and learning errors. In general, the factors that cause students to make errors are students do contextual questions less often, students are more inclined to memorize formulas compared to understanding concepts, and lack of material deepening.

Based on the data contained in Table 2, there were still some student errors in solving math problems related to the topic of solid geometry. Most of the research related to this study will be published in 2021, with five articles. The research method used in these studies is dominated by descriptive qualitative research, but there are two studies that use case study methods. Then, the research subjects related to this problem were not only junior high school class VIII and IX students, but there was one study that took participants from class XII vocational high school students.

Overall, these researches have identified and described the types of student errors in solving problems in detail to the causal factors. The

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researches also display mathematical problems given to students and provide examples of the results of students' answers. However, there are also some researches that still have not presented in detail the principles of error and their causes so the reader cannot obtain sufficient information related to students' errors in solving the problem of solid geometry.

Errors are simple symptoms experienced by students while studying (Luneta, 2015). According to Ulifa and Effendy (2014), the definition of error is a deviation from what is believed to be true or something that is expected (Yanuarto & Romadona, 2021). So that an error is a deviation from something that is true when students learn. Error analysis has an important role in learning mathematics because it can be used to detect the location of students' difficulties in solving problems (Farida, 2015). There are various methods of error analysis that can be used to classify student errors in learning mathematics. These studies use errors based on the stages of problem-solving Polya, Newman Error Analysis, Nolting, and other error theories. Based on these types of errors, in general, student errors include conceptual errors, procedural errors, and errors in writing answers.

The following types of student errors are listed in Table 3.

Table 3. Types of student errors

No.	Type of Error	Detail	References
1.	Reading error	Students cannot recognize symbols or mathematical notations in the given problem. These types of errors include the Newman Error and the Nolting error theory.	(Fiqri et al., 2016); Darmawan, Kharismawati, Hendriana, & Purwasih, 2018; Lestari, Aripin, & Hendriana, 2018; Pratiwi & Anita, 2021; Amni & Kartini, 2021; Ulpa, Maharani, Marifah, & Ratnaningsih, 2021)
2.	Comprehension error	Students misunderstand the given problem because they have not mastered certain material concepts. This type of error is included in the Newman Error Analysis.	(Fiqri et al., 2016; Darmawan et al., 2018; Lestari et al., 2018; Pratiwi & Anita, 2021; Amni & Kartini, 2021)
3.	Transformation error	Students are incorrect in making mathematical models needed in problem solving. This type of error belongs to the Newman Error Analysis.	(Fiqri et al., 2016; Darmawan et al., 2018; Lestari et al., 2018; Amni & Kartini, 2021)
4.	Process skill error	Students are incorrect in doing calculations or changing a unit. This type of error belongs to the Newman Error Analysis.	(Fiqri et al., 2016; Darmawan et al., 2018; Lestari et al., 2018; Amni & Kartini, 2021)
5.	Encoding error	Students are incorrect in writing the final answer or have not been able to write the answer completely. This type of error belongs to the	(Fiqri et al., 2016; Darmawan et al., 2018; Lestari et al., 2018; Amni & Kartini, 2021)

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ISSN 2442-5419 (Online)

DOI: https://doi.org/10.24127/ajpm.v11i3.5193

No.	Type of Error	Detail	References
		Newman Error Analysis.	
6.	Concept error	Students are incorrect in solving problems because they do not understand the concept or principle of a material. This type of error is also included in the Nolting error theory.	(Yan, Bistari, & Hamdani, 2013; Istiani & Hidayatulloh, 2017; Kurniawati, 2018; Atiqoh, 2019; Hidayat, 2019; Hutajulu, Senjayawati, & Minarti, 2019; Ifasiroh, 2019; Mazlan et al., 2020; Ulpa et al., 2021)
7.	Procedure error	Students have understood the problems they are facing and know what steps must be taken but at the implementation stage it is still incorrect.	(Yan et al., 2013; Hidayat, 2019; Hutajulu et al., 2019; Mazlan et al., 2020)
8.	Calculation error	Students do arithmetic operations incorrectly, such as addition, subtraction, multiplication and division.	(Yan et al., 2013; Istiani & Hidayatulloh, 2017; Hidayat, 2019; Prihatini & Setiawan, 2020; Yulianti & Novtiar, 2021)
9.	Error receiving information	Students mistype information related to things that are known and asked in the questions.	(Istiani & Hidayatulloh, 2017)
10.	Error related to prerequisite material	Students are wrong in solving problems because the prerequisite material is not well understood, for example on the topic of solid geometry, students must understand quadrilateral topics.	(Istiani & Hidayatulloh, 2017)
11.	Language interpretation error	Students misinterpret everyday language or certain symbols into mathematical language.	(Atiqoh, 2019)
12.	Technical error	Students incorrectly manipulate algebraic operations or change a unit	(Atiqoh, 2019; Hutajulu et al., 2019; Ifasiroh, 2019; Mazlan et al., 2020; Yulianti & Novtiar, 2021)
13.	Error in using data	Students do not use the data listed in the problem, add data that is not needed in solving the problem, and incorrectly enter data into certain variables.	(Atiqoh, 2019; Ifasiroh, 2019)
14.	Error in making conclusion	Students draw conclusions but are not based on facts and are not in accordance with the instructions on the question	(Atiqoh, 2019; Prihatini & Setiawan, 2020)
15.	Data interpretation error	Students misinterpret a mathematical notation or symbol	(Hidayat, 2019; Ifasiroh, 2019; Prihatini & Setiawan, 2020)

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No.	Type of Error	Detail	References
16.	Error in checking answers	In the fourth Polya problem solving stage, students make mistakes so they cannot prove the answers obtained are correct or not	(Yulianti & Novtiar, 2021)
17.	Directional error	This type of error is included in the Nolting error theory, where students misunderstand directions	(Ulpa et al., 2021)
18.	Careless error	Students are incorrect because they are in a hurry to solve problems. This type of error is also included in the Nolting error theory.	(Hidayat, 2019; Pratiwi & Anita, 2021; Yulianti & Novtiar, 2021; Ulpa et al., 2021)
19.	Implementing error	This type of error is included in the Nolting error theory, where students know strategies to solve problems but cannot apply them.	(Ulpa et al., 2021)
20.	Test error	This type of error belongs to the Nolting theory error, where errors occur in certain things. For example, students cannot complete the work of the given question.	(Ulpa et al., 2021)
21.	Study error	This type of error is included in the Nolting theory error, where students do not learn certain material because of insufficient time so that the student makes errors.	(Ulpa et al., 2021)
22.	Pseudo Construction "Correct" error	Students write the correct answer but incorrectly distribute the classification of answers.	(Wulandari et al., 2021)
23.	Pseudo Construction "incorrect"	Students write wrong answers but their way of thinking is right	(Wulandari et al., 2021)
24.	Construction hole	Students write the right answer but found a mismatch in the construction process of a concept	(Wulandari et al., 2021)
25.	Mis-analogical construction error	Students write wrong answers when comparing between concepts	(Wulandari et al., 2021)
26.	Mis-logical construction error	Students write incorrect answers caused by the lack of students' reasoning abilities	(Wulandari et al., 2021)

Based on Table 3, in general, student errors include conceptual errors, procedural errors, and errors in writing answers. In solving the problem of solid geometry, the most common student errors encountered were conceptual errors. Conceptual errors are errors where there is a lack of knowledge related to concepts because they do not understand basic facts, concepts, and

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skills (Makhubele, Nkhoma, & Luneta, 2015). The indicators of conceptual error put forward in the research of Ulpa et al. (2021), including students who do not know the concepts, ideas, or mathematical principles needed in solving problems and do not know the properties and concepts related to the solid geometry's topic. The following are examples of student errors in the research of Mazlan et al. (2020).

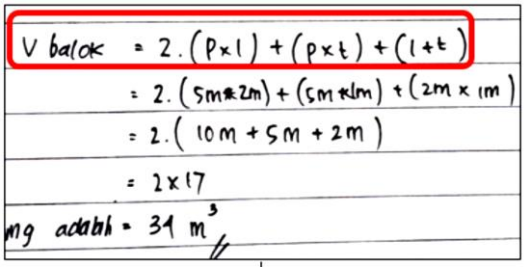

Figure 1. The Example of Conceptual Error

Based on the results of student answers contained in Figure 1, students cannot choose the right formula for solving problems. In this problem, students are asked to find out how many liters of water will be filled in the tub in the form of a cuboid. The form of conceptual errors made by students leads to the use of formulas that are not supposed to, for example, students use the formula for the surface area even though students should use the volume formula (Mazlan et al., 2020). This is in line with research conducted by Istiani and Hidayatulloh (2017) which suggests that errors in applying are caused by a lack of accuracy and students who do not understand the problems given. As for the errors related to the concept of solid geometry that were put forward in the study, formulation errors, errors in determining surface area, errors in determining volume, errors in determining the base and cover of a prism, and errors in determining the shape of the requested space.

Then, there are examples of student answers in Hidayat (2019) which suggests that students make conceptual errors in problems related to the shape of a cube. The information contained in the problem is the length of the diagonal of a cube, then students are asked to determine the surface area of the cube. The following is an example of a student's answer that made an error.

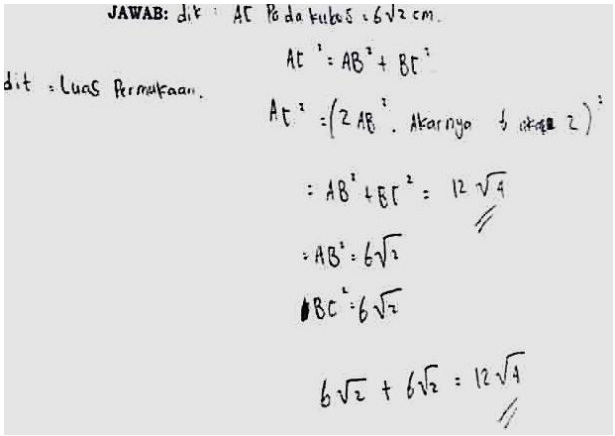

Figure 2. The other example of conceptual errors

Based on the results of student answers contained in Figure 2, students have not been able to use the concept of the Pythagorean theorem which is used to determine the length of the side of a cube. According to the results of interviews, students have not been able to perform arithmetic operations on the

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multiplication of numbers in the form of roots which causes students to make errors (Hidayat, 2019).

There are several factors that cause conceptual errors, including students who have not mastered concepts such as how the surface area and volume of a shape are, do not understand the concept of prerequisite material needed in the problem-solving step, and have not been able to determine formulas or formulas in solving problems, and there is holes concept construction.

The results of this study are in line with the research proposed by Istiani and Hidayatulloh (2017) which also discusses the types of conceptual errors related to prerequisite material. In this study, errors related to prerequisite material include errors in changing units, errors in adding irrational numbers, errors in using the Pythagorean formula, errors in determining the diagonal of a rhombus, and errors in using the concept of triangles.

Students' errors can be seen when students are faced with problem solving, both mathematical problems and problems outside the context of mathematics. Problems faced by students can be routine problems or non-routine problems. Analyzing students' errors in solving solid geometry problems can help educators, one of which is identifying the forms of student difficulties in the learning process. Hence, educators are required to find out how should be taught mathematics and assist students in training in problem solving.

CONCLUTION AND SUGGESTION

Based on the explanation above, it can be concluded that there are student errors in solving problems related to the solid geometry with the most dominant error, namely conceptual errors. This is because students have not mastered the concept of solid geometry and the concept of prerequisite material and have not been precise in determining the formula used in solving problems related to solid geometry.

Although the topic of solid geometry is one of the topics studied in junior high school, solving problems in this topic also allows for errors to occur in students with higher education levels, one of which is vocational high school. Therefore, the need for non-routine questions to be given to students so that they are accustomed to solving problems related to solid geometry and other math topics.

This study is expected to add insight into research in the field of mathematics education, especially in reviewing student errors in solving the problem of solid geometry. Then, the results of this study are recommended to be studied in more detail by processing them in the form of meta-synthesis.

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