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IMPLEMENTATION OF NEWMAN METHOD FOR ANALYZING STUDENT ERRORS IN SOLVING HOTS TYPE MATH PROBLEMS

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Abstrak

Kemampuan berpikir kritis merupakan salah satu kemampuan yang dibutuhkan dalam pembelajaran, namun pada kenyataannyan kemampuan berpikir siswa Indonesia masih cukup rendah. Lemahnya kemampuan siswa dalam mengembangkan daya menalarnya pada penyelesaian masalah dalam pelajaran matematika terkhusus pada soal-soal HOTS menyebabkan siswa kesulitan serta banyak mengalami kesalahan saatmenyelesaikan soal-soal bentuk cerita. Tujuan dari penelitian ini adalah mendeskripsikan kesalahan yang dilakukan siswa dalam menyelesaikan soal matematika bertipe HOTS berdasarkan prosedur Newman. Penelitian ini menggunakan pendekatan kualitatif dengan metode deskriptif. Subjek penelitian ini adalah siswa kelas XII SMA berjumlah 13 siswa. Teknik pengumpulan data berupa tes, wawancara dan dokumentasi. Keabsahan data menggunakan triangulasi metode yaitu menggunakan metode wawancara, observasi, dan survey. Hasil penelitian menunjukkan bahwadalam mengerjakan soal cerita materi dimensi tiga dan statistika persentase kesalahan paling banyak dilakukan pada tahap penulisan jawaban akhir dengan persentase 90,38%, kemudian diikuti oleh kesalahan memahami dengan persentase 61,53%, selanjutnya kesalahan transformasi dan kesalahan proses denan persentasesebesar 23,07% dan kesalahan membaca soal sebanyak 1,85%.

Kata Kunci: TipeHOTS; Dimensi Tiga; Statistika;Kesalahan Siswa; KriteriaNewman

Abstract

Critical thinking ability is one of the skills required for study, but in reality, the thinking ability of Indonesian students is still very low. Students' problem-solving skills in math classes, especially HOTS problems, have weaker developmental abilities, leading to difficulties and mistakes in solving problems in the form of stories.The purpose of the study was to describe the mistakes students make when using the Newman method to solve HOTS-type math problems. This study used qualitative and descriptive methods. The subjects of this study were 13 students in twelve classes of senior high school. Data collection techniques in the form of tests, interviews, and documents.Data validity using triangulation methods using interviews, observations, and survey methods.The results showed working on the problem of three-dimensional material stories, and statistical percentage of errors was mostly done at the writing stage of the final answer with a percentage of 90.38.followed by misrepresenting with a percentage of 61.53%, then transformation errors and process errors with a percentage of 23.07%, and error reading problems as much as 1.85%.

Keywords: *HOTS type; Three Dimensions; Statistics; Student Errors; Newman Criteria*

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INTRODUCTION

Educational evaluation is part of the learning strategy that is viewed from social learning theory is part of reinforcement strategy that has the goal to foster the expected attitude and ability such as high work ethic, discipline, and continuous learning (Salirawati, 2021), (Sardiyanah, 2020). Evaluation of quality learning will help correct the learning process so that it will be able to improve the quality of education. Divayana & Sugiharni (2016) states that evaluation is a process of assessing the achievement of goals and disclosing program performance problems to provide feedback for improving the quality of performance of the program or activity. In the learning process, evaluation is a very important part (Basri, 2017), The same thing is also stated by Pramesti (2019) that learning evaluation aims to obtain accurate information about the achievement of learning objectives for further decisions to be made about the follow-up.

Mathematics is a science that aims to train students to think critically, logically, creatively, and have an effective work will (Badjeber & Purwaningrum, 2018). In mathematics, studying mathematics is not just memorization, but must be able to denote each mathematical symbol, because mathematical symbols are "artificial" which will have meaning after meaning is given to it (Martua Manullang, 2014). The problem that is often encountered in mathematics lessons is that students have difficulty solving questions or questions in the form of story questions. Mathematics is a science that aims to train students to think critically, logically, creatively, and have an effective work will higher order thinking skills (HOTS). HOTS is a domain of cognitive processes that are included in the ability to think at a high level, namely analyzing, evaluating, and creating (Shalikhah et al., 2021). HOTS questions in mathematics learning are questions designed to measure students' high-level thinking ability in solving story shape problems.

Newman's theory is designed as a simple diagnostic procedure for analyzing students' errors in solving mathematical story problems in which there are five indications of error types. (Sari et al., 2018). As for some research related to the Newman theory such as Magfirah et al (2019), the Newman procedure can be used to determine the type of student error that is (1) error reading the problem; (2) misrepresentation of the problem; (3) Transformation error; (4) process errors; (5) Error writing the final answer. The same pendapdat is also put forward by (Wae et al., 2020) (Alhassora et al., 2017). In line with the above statement Maulana & Pujiastuti (2020) also argues that Newman's theory is contained in it, namely student misconceptions in reading problems (reading), students making mistakes when understanding the core of the problem (comprehension), and students making mistakes in doing problems using formulas and appropriate steps (process skills). The material taken is third dimension and statistics because it is found that there are still many students who have difficulty solving story problems in third-dimensional material and statistics (Maulana & Pujiastuti, 2020).

The three-dimension is one of the mathematical sciences of field discourse, points, and lines (Novita et al., 2018). The many three-dimensional dilemmas/problems that require careful solving require students to think

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carefully and carefully as well. The factor causing students' mistakes in answering the questions is that students have difficulty illustrating images with commands on the questions, as a result of which the student's value becomes low. Here is some research on analyzing student errors in the field of three-dimensional focus has been done a lot such as (Hendrayanto et al., 2021) Mistakes made by research participants in solving mathematical problems in building space geometry are (1) errors in understanding the meaning of a problem (comprehension errors); (2) transformation errors; (3) process skill errors; (4) encoding errors. The same opinion was also expressed by (Azhar & Senjayawati, 2021). The findings of this study are supported by research conducted by (Ayuningrum et al., 2019).

While statistical material is one of the mathematical materials studied by high school students in odd semesters (Silviani et al., 2021). The low learning outcome of students in statistical materials is considered by researchers in choosing this material. The causative factor is that students have not understood the basic concepts of statistics, communicated problems by modeling mathematics, and drew conclusions or conclusions. It is because the frequency distribution table, median, and mode have a variety of formula concepts that make it difficult for students to solve the given problem. Based on the research by Ashidiqi & Setiawan (2021) revealed that the difficulty of students in working on questions on statistical material that the most errors made by students was in question number 1, which has an indicator of choosing the median on a data using an error percentage of up to 90% (including very high criteria). The factors causing the number of errors made by students are not understanding the concept of the problem and not being careful in working on the questions given. The same thing was also expressed by (Suryanti et al., 2020), (Utami et al., 2020), and (Lestari et al., 2018). Therefore, learning to use HOTS story questions needs to be developed. As for obtaining information related to the types of mistakes made by students, teachers can use it as a reference in determining the appropriate learning design to minimize the occurrence of errors in solving similar story problems.

Based on the description above, the purpose of this research is to describe the mistakes made by students in solving HOTS problems in third-dimensional materials and statistics based on Newman's procedure.

RESEARCH METHOD

During the two meetings, tests and interviews were conducted. The type of research used is qualitatively descriptive. This research aims to make an in-depth, systematic, and factual picture of the mistakes made by high school students in solving story problems based on Newman's procedures and the causes of errors. The description of this study was done by providing an overview of the errors in resolving HOTS problems based on Newman's procedures. The stages of research passed in the study include (1) observation; (2) taking the final test value for the homogeneity of the sample; (3) compiling questions and answer keys; (4) providing as 90-minute student cohesiveness test; (5) evaluate the student's answer key; (6) data analysis, interpretation, drawing conclusions.

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Research instruments used in this study in the form of essay tests consists of 4 with an indicator (1) the ratio of the volume of limas and cubes; (2) the distance of the point to the plane; (3) the relationship between the average and the amount of data; (4) the relationship of average and data reach, questions, interview tests, and document results. After collecting data, the researcher analyzes the data and then interprets it, and the latter makes conclusions based on the data obtained. So it can be concluded that the Newman procedure is a method for analyzing errors in the description problem (Fitri et al., 2019).

The indicators contained in the Newman procedure are as follows.

$$P_i = \frac{Ei}{N \times Mi} \times 100 \qquad (1)$$

P_i is the percentage of student errors, E_i is the number of errors, N is many students, and M_i is many problems. The data analysis procedure includes (1) checking students' answers; (2) determining general or classical completeness; (3) coding the location of student errors; (4) determining the percentage of the student's error rate using equation (1); (5) classify errors based on the criteria of reading, comprehension, transformation, process skills, and encoding.

Table 1. Newman error indicator

No	Types of Errors	Indicators
1	Reading	a. Identify information and mathematical symbols in full b. Identify mathematical information and symbols appropriately c. Incorrect in identifying information and mathematical symbols d. Not answering
2	Comprehension	a. Write down the formula to be used appropriately b. Writing that is known but does not correspond to problem c. Wrong in writing known and asked d. Not answering
3	Transformation	a. Write down the formula to be used appropriately b. Write down the formula to be used but not appropriate (miswritten / wrong) c. Write the formula to be used with but not by the request of the problem d. Not answering
4	Process skill	a. Using the right process and the right answer b. Using the right process but the wrong answer c. Using the wrong process and wrong answers d. Not answering
5	Encoding	a. The correct conclusion b. Incorrect conclusions c. Wrong conclusion d. Not answering

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RESULTS AND DISCUSSIONS

1. Validation Results of HOTS

The problem will be validated first before being tested on students in advance. Mathematical materials experts and linguists have validated the problem.It aims to determine whether theproblem is made worthy or not to be given to students. What is considered is in terms of language and from the most important. Based on the validation results of hots, the details can be seen in Table 2.

Table 2. HOTS problem validation results

No	Expert	Average	Category	Note
1	Material	7,2	Very Worthy	Instructions on the problem clarity about being known and asked from the problem and the problem must be by the material basic competence.
2	Language	4,8	Proper	The use of problem attributes/ punctuation, sentences used must be clear and easy to understand.

Table 2 describes the value of the problem validation results by linguists and material experts which shows that the material validation value obtained is 7.2 in the very worthy category, and the language validation value of 4.8 is included in the proper category.

2. Student Error Rate

After research, the average students made the most (1) mistakes when writing their final answers; (2) false statements. Both metrics are among the top mistakes students make. It can happen due to a lack of understanding by the student, or it can be due to a student's inattention to reading problems, which leads to frequent errors. Based on the above description, the detailed data on students' errors in the twelfth lesson of the history of three-dimensional materials and statistics in the Newman theory stage are shown in Table 3.

Table 3. Types of student errors in money solve problems based on Newman's theory

No	Name	Score			
		1	2	3	4
1	S'01	C,E	E	E	T,C,P,E
2	S'02	C,E	C,E	E	T,C,P,E
3	S'03	C,E	C,E	E	R,T,C,P,E
4	S'04	C,E	C,E	E	T ,C,P,E
5	S'05	C,E	C,E	E	T,C,P,E
6	S'06	C,E	E	E	T,C,P,E
7	S'07	C,E	C,E	E	T,C,P,E
8	S'08	C,E	C,E	E	T,C,P,E
9	S'09	C,E	C,E	E	T,C,P,E
10	S'10	B	E	E	E
11	S'11	C	C,E	E	T,C,P,E
12	S'12	B	E	B	T,C,P,E
13	S'13	C,E	C,E	B	T,C,P,E

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Information:
B : Correct answer
C : Incorrect representation
X : No response
P : Capability error
R : Read error
E : Error writing final answer
T : Conversion error

Table 3 describes where students' mistakes are in answering HOTS questions according to Newman criteria. After looking at the error data for each student in Table 3 it can be seen that there are still many students making mistakes at the level of Newman's theory. Student's mistakes are reading mistakes, misrepresentation of questions, conversion mistakes, skill processing mistakes, and mistakes in writing final answers. Table 3 shows that of the 13 students who worked on the story of third-dimensional material and statistics based on Newman's error criteria, two students answered question no. 1 correctly, two students answered correctly question no. Three and the remaining nine students could not answer the real given question correctly. Based on the data results obtained, one student correctly answered 2 of the four questions given, and two students correctly answered 1 of 4 questions. The following presented a recapitulation of the percentage of student errors based on Newman's theory in Table 3. As for the results of percentage errors of students' answers in solving math problems of hots type of three-dimensional material and statistics obtained as follows in Table 4.

Table 4. Percentage of student errors

Problem Number	**Type of error**				
	E1	**E2**	**E3**	**E4**	**E5**
1	0	11	0	0	10
2	0	9	0	0	13
3	0	0	0	0	11
4	1	12	12	12	13
Sum	**1**	**32**	**12**	**12**	**47**
Percentage	**1,85%**	**61,53%**	**23,07%**	**23,07%**	**90,38%**

Information:
E1 : Misreading Questions
E2 : Error of understanding
E3 : Transformation Error
E4 : Proccess error
E5 : Final answer writing error

Table 4 describes the percentage of student error results in answering HOTS questions based on Newman criteria. Based on Table 4, it is seen that the most errors are recorded at the writing stage of the final answer with a percentage of 90.38%. Followed by the examination with a percentage of 61.53%, transformation errors 23.07%, and error reading questions as much as 1.85%. Based on the description, it can be concluded that the most student error rate with the largest percentage is at the stage of writing the final answer and the error of understanding the problem.

3. Analysis of Problem Errors With Newman Criteria

This discussion will be presented data on the results of research based on

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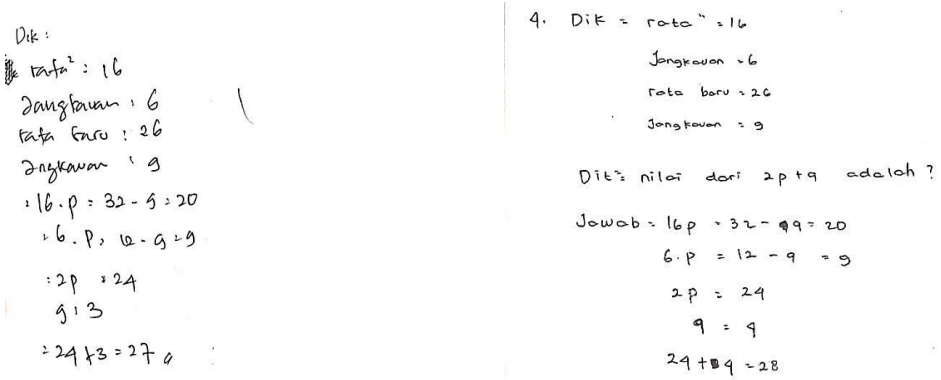
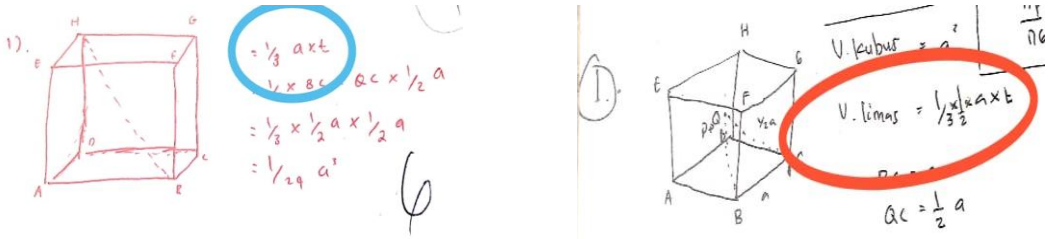
the results of student work. Furthermore, the location of errors in resolving HOTS problems with Newman criteria will be known from these results. The description of the student's answer can be seen in Figure 1.



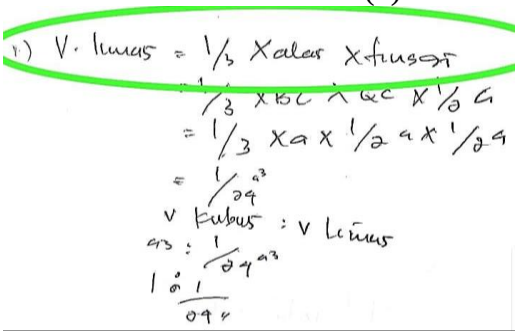
(a) low-skilled student (b) medium-capable students

Figure 1. Error reading questions

Figure 1(a) shows that S'03 students experienced reading errors because S'03 students misrepresented the grades mentioned in the problem. Where is the problem?The new grade point average is 20, but S'03 students write 26. In addition, S'03 students also do not write keywords precisely, i.e., the word New Reach but by students S'03 only written the word Reach.So it will be difficult to distinguish the value of the New Reach from the value of the old Reach due to the absence of clear information. Figure 1(b) shows that S'02 students experience the same reading errors as S'03 students, and this so that at a later stage, students experience errors.



(a) low-skilled students (b) medium-capable students



(c) capable students tall

Figure 2. Error of understanding

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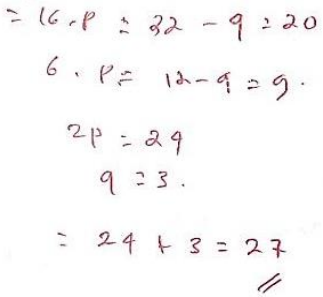
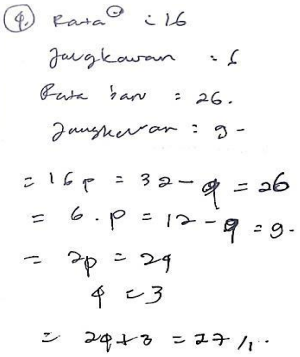
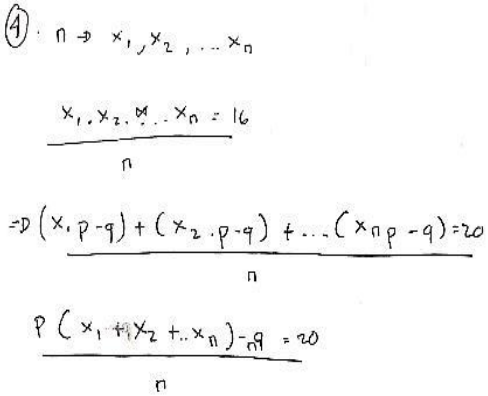
Figure 2 shows that the S'10 student seen in figure (a) made a misrepresenting, where the request was "volume limas P.BCQ be $\frac{1}{3} \times Luas\ alas \times t$ " but S'10 students write the same formula that is $\frac{1}{3} \times a \times t$, then in the image (b) S'13 students experience the same error of understanding, where S'13 students write the formula volume limas P.BCQ, which is $\frac{1}{3} \times \frac{1}{2} \times a \times t$,and the last picture (c) where S'11 students also make misrepresenting, S'11 students write formulas, not by the request of the problem that is 1/3 x alas x t so that in the next stage students experience errors. In addition, of the three other misrepresented students who did not write down what they did Know and Asked. However, the final result is correct in completing the three students using the wrong formula. There illustrated that students do not understand what is written or do not know what problems to solve.



(a) low-skilled students



(b) medium-capable students



(c) capable students tall

Figure 3. Transformation Errors

Figure 3 of section (a) shows the student's error at the transformation error stage, where the S'10 student incorrectly determines the formula to be presented. The formula used should be yes $\frac{x_1+x_2+\cdots+x_n}{n}$ = 16. However, S'10 students do not use the formula. Figure 3(b) also shows the same error where S'08 students make transformation errors, namely errors using formulas where the formula used does not match the request of the problem so that the completion step and the results obtained are wrong. While the last image is the image (c) of S'13,

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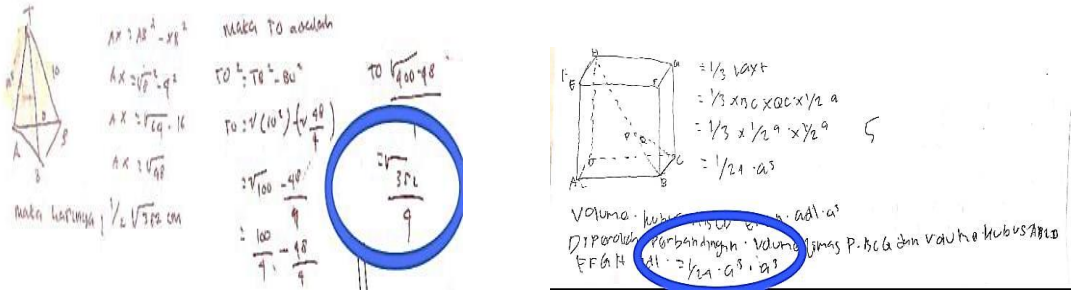
students can correctly write the formula and solve the problem.

The next explanation is about process skill error. The answer of the students are showed in Figure 4.

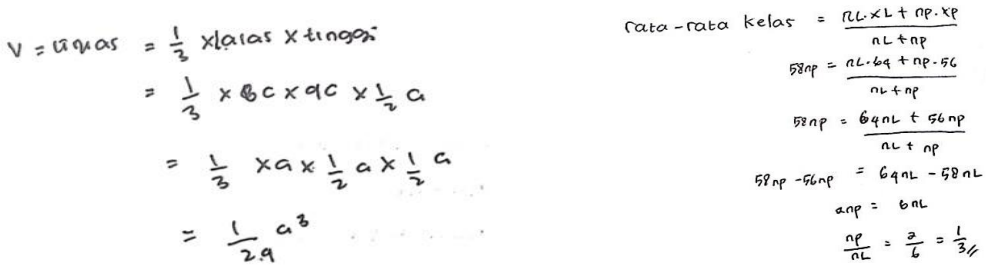


(a) low-skilled students (b) medium-capable students

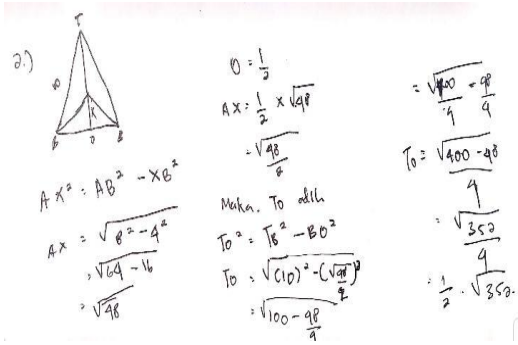
Figure 4. Process skills errors

Figure 4, part a, shows that students make process skills mistakes where S'10 students cannot continue the calculation process until completion. Where in question number 2, the results that should be obtained are "$\frac{1}{2}\sqrt{352}$" but because students of S'10 do not continue the problem, the results that can be not perfect are."$\frac{\sqrt{352}}{4}$". Next, in figure 4(b), where the student makes the same mistake but on a different problem. S'09 students also cannot finish the problem until it is over. Where in question number 1, the results requested by the problem are"$\frac{1}{24} : 1$" While by S'09 students the results obtained are " $\frac{1}{24}a^3 : a^3$ " and these results are not under the request of the matter.

The last type of Newman's error is final answer writing error. The students answer especially about this type are showed in Figure 5.



(a) low-skilled students (b) medium-capable students



(c) capable students tall

Figure 5. Final Answer Writing Error

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Figure 5 shows that the S'01 student shown by figure 5(a) made the mistake of not writing the conclusion of the final answer and not finishing the question until the end. Diaman final answer is very important written as a form of conclusion of the description of the settlement made. In figures 5(b) and5(c), students with codes S'03 and S'15 have answered the question correctly, but students do not write the conclusion of the final answer of the settlement. So it can be concluded that the three students can not make the final answer conclusion.

Based on the researchers' observations of the test results, some of the study subjects did not write down known elements, asked and formulas. Suppose the subject is directly on the solution of the problem. Newman's procedure leads students to work on the description questions regularly step by step. Working without going through stage by stage does not affect the process. After that, it indicates that students have different thinking styles. Therefore, it is important to give each individual the opportunity to perform their duties under personal strength. (Maghfiroh & Rohayati, 2020), (Triliana & Asih, 2019), (Magfirah et al., 2019). The findings of this study are supported by research conducted by (Ayuningrum et al., 2019) find that the factors that cause student error when answering the problem of the third dimension are (1) due to lack of mastery of the initial concept of the material; (2) students find it difficult to illustrate images under the request of the problem, especially in the three-dimensional problem; (3) Students pay less attention to the teacher when explaining, and that is because the student considers the three-dimensional space material difficult to learn so that the interest in learning is low. Then the research conducted by (Maryati 2017) finds that the student error factors in the statistical material of internal factors are (1) a lack of initial understanding of the material about statistics and; (2) student motivation in following the teaching and learning process. While external factors that affect student's learning difficulties are: (1) the classroom environment is) the lack of facilities and infrastructure that can support students in understanding the subject matter; (2) the applied learning model less motivates students to learn actively and creatively in understanding material lessons; (3) The family environment is less supportive in creating an atmosphere conducive to providing opportunities for students to do home study; and (4) the community environment is an uncomfortable environment for students to undertake broad insightful activities.

CONCLUSION AND SUGGESTION

There are five errors in working on the story of third-dimensional material and statistics made by class XII students. The five errors are the percentage of errors mostly done at the writing stage of the final answer with a percentage of 90.38%, then followed by errors of understanding with a percentage of 61.53%, then transformation errors, and process errors with a percentage of 23.07% and error reading questions as much as 1.85%.

The suggestions given to this problem is (1) that teachers can use the right learning methods to explain teaching materials to students to be better established. (2) Teachers can emphasize understanding in teaching materials and train students by providing HOTS questions to stimulate students' reasoning power in critical

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thinking. In addition, giving story questions can train students to find important information in the question and familiarize students to devise mathematical models that are by the demand for problems.

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