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ANALYSIS OF STUDENT ERRORS IN SOLVING STUDENT MATHEMATICS UAS QUESTIONS ACCORDING TO CASTOLAN CRITERIA

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ABSTRACT

This study aims to analyze the errors made by students in completing final semester exam (UAS) questions in the field of mathematics, namely linear programming, matrices and transformation geometry. The subjects of this study were students of class XI Nursing at SMK Kesehatan Indonesia Jaya Parigi. In determining the research subjects, *purposive sampling technique was used* . The data collection technique for this study used documentation of essay questions for the final semester exam and documentation of student answer sheets and interviews. The data analysis technique used according to Miles and Huberman is condensation of UAS and interview results data, presenting UAS and interview results data and drawing conclusions. The results of this study indicate that the errors made by students are conceptual errors, procedural errors and technical errors. Indicators of conceptual errors made by students are not being able to interpret problems/use terms, concepts, and principles, students are not able to choose formulas/properties correctly and students are not able to apply formulas/properties accurately. Indicators of procedural errors are inconsistencies in the solution steps with the questions asked and not being able to complete the questions until the final stage. Indicators of technical errors are errors in arithmetic operations and errors in moving numbers or arithmetic operations from one step to the next. Factors causing errors made by UAS participants are not understanding the questions well, lack of mastery of concepts in Matrix, Linear Programs and Transformation Geometry materials, rarely practicing reworking examples of questions, students only see and read examples of questions.

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1. INTRODUCTION

Mathematics is a basic science that continues to develop both in terms of theory and application (Nurjanatin et al., 2017) . Therefore, in the world of education, mathematics is studied by all students from elementary school to college level. Also included in the Vocational High School (SMK) level. According to Magfirah et al., (2019) , one of the things that supports the development of education is mathematics. Mathematics is very important to learn in schools, so that students are able to count, reason, and solve problems in everyday life. Considering the important role of mathematics for students, mastery of mathematics material from an early age needs to be improved both in terms of mindset and application.

Mathematics is a science that plays a role as a tool to solve a problem. This is supported by the opinion of Rusmana, (2019) who stated that mathematics is an important tool for students when they face problems and challenges in personal, work, community, and scientific aspects of their lives . In order to optimally explore students' mathematical abilities, teachers must be able to understand the circumstances of their students. One way to understand students is to know their weaknesses or mistakes in solving math problems. Error analysis can be done to find out the mistakes or weaknesses made by students in solving math problems during exams at school.

Examinations held at schools are an assessment of learning outcomes by the Education Unit which aims to assess the achievement of graduate competency standards for all subjects. The Final Semester Exam (UAS) is an instrument for conducting final semester assessments. UAS is an activity carried out by educators to measure students' competency achievement at the end of the semester. The exam coverage includes all indicators that represent all basic competencies in that semester.

Based on the results of interviews with teachers and students about mathematics subjects at SMK Kesehatan Indonesia Jaya Parigi via WhatsApp and direct interviews, and prospective researchers also participated in observing student learning, information was obtained that the lack of understanding of SMK Kesehatan Indonesia Jaya Parigi students in mathematics material so that when working on the Final Semester Exam (UAS) mathematics questions in the odd semester of the 2022/2023 school year that the mathematics teacher gave, the grades the students got were low.

The low mathematics scores of students are due to the mistakes made by students in completing the final exam mathematics questions. Santi & Sudihartinih, (2019) stated that mistakes are deviations from the truth made by students as a form of difficulty they experience when learning. The existence of errors made by students when working on UAS questions needs serious attention in order to support a good and ongoing learning process because mathematics material is interrelated material, where students will have difficulty understanding the next material if they are unable to understand the material taught previously. Errors in the process of working on questions can be an indication of the extent to which students are able to master the material that has been studied. Errors made by students can be researched and studied in more depth based on error analysis with the Kastolan criteria.

According to Kastolan *in* Kosasih, (2020) error is a deviation of someone who has believed something that it is true that has been agreed upon together beforehand. Problems in mathematics subjects are usually found in the form of mathematical problems or questions given to students to find solutions. One way that can be used to identify errors made by students is by using error analysis based on the Kastolan criteria. The Kastolan criteria look at students' mathematical errors based on three things, namely conceptual errors, procedural errors, and technical errors (Lutfia & Zanthy, 2018) . The Kastolan criteria can help researchers analyze student test results and find out the types of errors that students might make.

Mistakes made by students cannot be separated from the existence of influencing factors. Febriansari, (2020) stated that the factors causing difficulties in working on mathematics problems include students' confusion in determining mathematical models, lack of student accuracy, and also a hasty attitude in solving problems. According to Ramadhini & Kowiyah, (2022) the factors that cause students to often make mistakes are because students do not study the concept of story problems enough, are in a hurry to answer, lack of accuracy, and lack of student logic.

2. METHOD

This research is a research with a qualitative approach. The type of research taken is descriptive qualitative research. because this study aims to describe the types of errors and factors causing students' errors in solving UAS mathematics questions based on the Kastolan criteria. This study was conducted at SMK Kesehatan Indonesia Jaya Parigi, which is located in Maesa Village, Parigi, Parigi Moutong Regency, Central Sulawesi Province. This research was conducted in the 2022/2023 academic year, even semester. The subjects in this study were grade XI nursing students in the 2022/2023 academic year. Selection of research subjects using *purposive sampling techniques.* Then the selection of research subjects by considering certain things: (1) Students' mathematical abilities, (2) Students who make more mistakes based on the Kastolan criteria, (3) Different mistakes, (4) Representing mistakes made by other students, (5) Recommendations from mathematics teachers . Data collection techniques in this study are documentation and interviews. The instruments used in this study are divided into two, namely the main instrument (*human instrument*) and supporting instruments.

Subject selection was carried out by documenting the final exam results sheets of grade XI mathematics of SMK Kesehatan Indonesia Jaya Parigi, then sorting and categorizing the final exam results sheets of mathematics to find out the description of student errors, after categorizing the researcher will see student errors based on the Kastolan criteria and select subjects based on these general characteristics. After getting the subjects, the researcher conducted interviews with the subjects to obtain supporting information. In testing the validity of data in qualitative research, internal validation is carried out by conducting a member check, namely providing text to students, followed by verification through interviews. Member check is the process of checking data obtained by researchers to data providers. The purpose of implementing this Member check is to determine the extent of the truth of the data provided by the informant . In this study, data analysis was carried out by referring to qualitative data analysis according to (Miles, dkk. 2014). Activities in data analysis, namely *data condensation* , *data display* , *drawing and* verifying conclusions.
The results of the students' Final Semester Exam (UAS) were analyzed using the Kastolan criteria. The following are error indicators based on the Kastolan criteria in table 1

Table 1based on Kastolan criteria

Error Type	Indicator
Conceptual Error	1) Students are unable to interpret problems using terms, concepts and principles. 2) Cannot select formula/property correctly 3) Unable to apply formula/property accurately
Procedural Error	1) The solution steps do not match the question asked 2) Unable to resolve the problem until the final stage
Technical Error	1) Error in calculation operation 2) Error in moving arithmetic operations or numbers from one step to another.

Source: *Meilanawati & Pujiastuti, (2020)*

3. RESULTS AND DISCUSSION

3.1. RESULTS

The implementation of the research includes two stages, namely documentation and interviews. The results of this study will be described from the two stages of data collection.

1. Documentation

After documenting the results of the final semester exam (UAS) mathematics questions for class XI nursing students at SMK Kesehatan Indonesia Jaya Parigi in the odd semester of the 2022/2023 academic year. It was found that only a few students were able to answer the exam

questions and still made mistakes when answering the questions. The final semester exam questions are essay or descriptive questions consisting of 10 questions from the material of Linear programs, matrices and transformation geometry.

2. Interview

After recapitulating the results of the students' UAS answers, the next step is to determine the students who will be the subjects in this study to conduct interviews. The determination of this subject is done using the *purposive sampling* technique . Then the selection of research subjects by considering certain things: (1) Students' mathematical abilities, (2) Students who make more mistakes based on the Kastolan criteria, (3) Different mistakes, (4) Representing mistakes made by other students, (5) Recommendations from mathematics teachers, (6) Students' willingness to be research subjects. Each question will be selected one subject that fits the criteria to obtain information and if the information obtained from one subject is considered still lacking then another subject can be selected that fits the criteria to complete or obtain more credible information.

By conducting this interview, we can find out in detail the mistakes made by students in solving story problems on quadratic equations. Interviews were conducted by asking questions about the test results that students had taken. The questions were given based on a coherent interview guide.

1. Errors based on Kastolan Criterion in Linear Programming Problems

a) Conceptual error

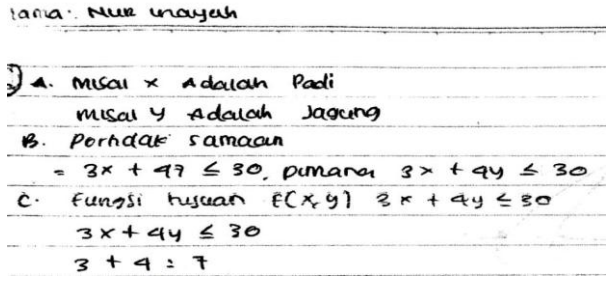


Figure 1Subject's answer to the linear programming question

Based on the answers of the subjects and interviews, data was obtained related to the errors made by the subjects, namely conceptual errors where the subjects were still unable to interpret the terms of the questions into the mathematical model the subjects did correctly, and did not understand what was meant by the objective function and could not write the objective function that the question wanted correctly. The subjects admitted that they did not understand the basic material of linear programming such as the linear inequality system and also did not understand how to determine the minimum value of a problem.

b) Procedural error

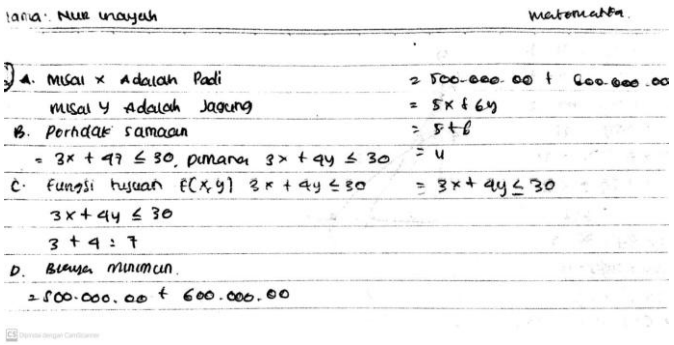


Figure 2: Subject's answer to the linear programming question

Based on the subject's answers and interviews, data was obtained regarding errors made by the subject, namely procedural errors. The subject was unable to complete the problem according to the steps the problem wanted and was unable to complete the problem until obtaining the final answer. The subject admitted to being confused about finding the minimum value of a function and the subject admitted to forgetting the procedure used when wanting to find the objective value of a function.

2. Errors based on Kastolan's criterion in Matrix problems

a) Conceptual error

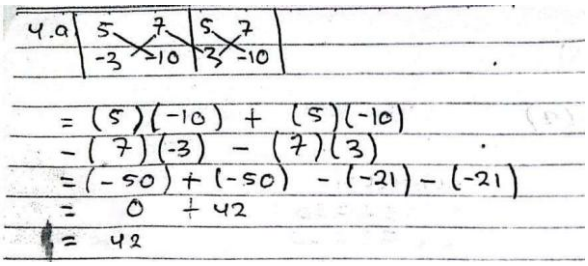


Figure 3: Student answers to matrix questions

Based on the answers and interviews, information was obtained regarding the errors made by the subject, when the subject wanted to find the determinant of a 2x2 order matrix, the subject did not understand the formula or concept of the determinant of a 2x2 order matrix, therefore it can be seen that the subject was looking for the determinant using the Sarrus rule, the subject was one of three UAS participants who answered with an inappropriate formula or concept so that the results obtained were less than accurate.

b) Technical error

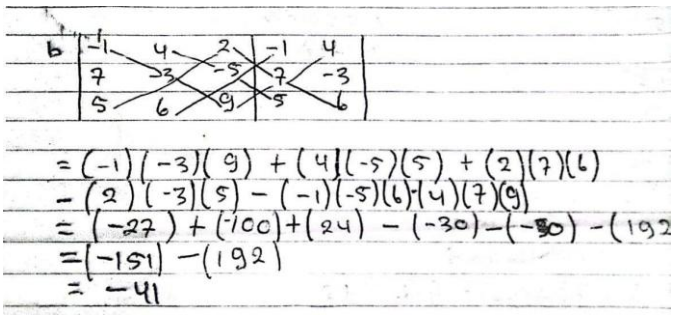


Figure 4: Student answers to matrix questions

Many technical errors were made by subjects when working on questions to find matrix determinants, the lack of basic mathematical understanding of integer arithmetic operations caused subjects to make mistakes when calculating integer multiplication operations. The subject was one of 10 UAS participants who still made many technical errors when answering this question, so that none of the 10 UAS participants were able to obtain the matrix determinant value correctly. The subject made a mistake in calculating the value of an arithmetic operation, namely integer multiplication (-1)(-3)(9) = -27, (2)(7)(6) = 24 and (4)(7)(9) = 192. This caused the conclusion or final answer obtained to be less than accurate.

3. Errors based on the Kastolan criterion in Transformation Geometry problems

a) Conceptual error

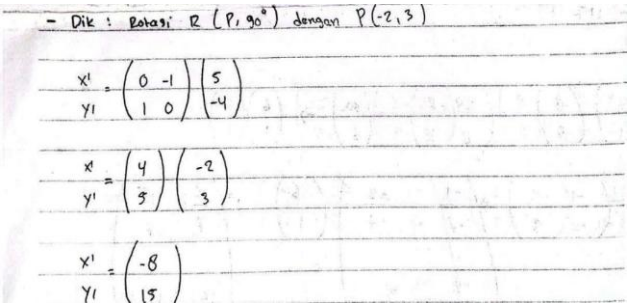
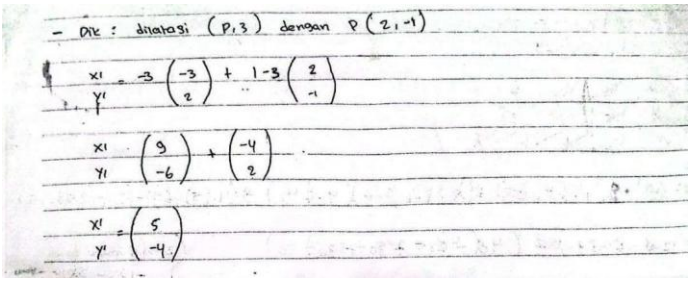


Figure 5: Student answers to transformation geometry questions

Based on the answers and interview results, information was obtained regarding the errors made by the subjects who made conceptual errors, due to misinterpreting the formula or not being able to write the correct formula for finding the shadow with rotation. The subject admitted to forgetting the formula used to find the rotation, so the results obtained were less precise.

b) Technical Error



Picture 6 student answers to transformation geometry questions

Based on the answers and interview results, information was obtained regarding the errors made by the subject who made technical errors when the subject incorrectly substituted the value, because he was not careful in reading the question, resulting in the question asking for dilation with (P, -3) the subject wrote the dilation with (P, 3) so that he did not get the correct dilation value.

Based on the analysis of the answers and interview results with students, it was found that students made mistakes in completing the final semester exam questions consisting of linear programming, matrix and transformation geometry materials, namely conceptual errors, procedural errors and technical errors. Conceptual errors are the inability to interpret problems using terms, concepts and principles, inability to choose formulas/properties correctly, and inability to apply formulas/properties accurately. Procedural errors are when the solution steps do not match the question asked and the problem cannot be solved to the final stage. Technical errors are errors in calculation operations and errors in moving calculation operations or numbers from one step to another.

3.2. DISCUSSION

The errors made by students participating in the UAS mathematics exam vary greatly in answering questions. Errors are classified using the Kastolan error criteria, where errors in answering questions are divided into three groups: conceptual errors, procedural errors and technical errors.

1. Conceptual Error
   Conceptual errors were made by subjects NI and SN on UAS question number 1 when the subject misinterpreted the concept of linear programming and was still wrong in interpreting the question, conceptual errors were also made by subject RF on question number 8 when the

subject forgot the correct linear equation formula, conceptual errors were made by subject IKW on UAS question number 3 when the subject could not choose the correct formula to find the value of an equation with a matrix inverse, conceptual errors were made by GA on question number 3 when the subject was less precise in applying the matrix inverse formula, conceptual errors were made by subject SN on question number 4 when the subject could not choose the correct formula when wanting to find the determinant value of a 2x2 matrix, conceptual errors by subject RF on question number 7 when the subject was not yet able to interpret the concept of matrix equations correctly, conceptual errors were made by subject SN when the subject did not understand the concept of matrix inverse on question number 10 and conceptual errors were made by subject IKW when the subject chose the wrong rotation formula on question number 5 of the transformation geometry material. This is in line with the opinion of Ulfa & Kartini, (2021) who stated that conceptual errors occur when students cannot interpret questions or use a term, concept, principle, conceptual errors also occur when students cannot choose a formula and cannot apply the formula correctly.

2. Procedural Error
   Procedural errors were made by subject NI on UAS question number 1 when the subject worked on the question but did not comply with the solution steps to obtain the minimum score in the linear programming material, procedural errors were made by subject GA on UAS question number 6 when the subject was unable to complete the question to the final stage, procedural errors were made by subject GA on UAS question number 3 when the subject worked on the question but did not comply with the solution steps in determining the value of the equation with the inverse matrix and procedural errors were made by subject IKW on question number 5 when the subject was unable to complete the question to the final stage. This is in line with the opinion of Firdaus, EF, Amalia, SR, Zumeira, (2021) who said that procedural errors occur when students do not complete the question according to the steps requested, students do not complete the question to the final stage or the simplest form and students do not write down the information that is known and asked.

3. Technical Error
   Technical errors were made by subject NI on UAS question number 1 when the subject made a mistake in calculating the value of the addition arithmetic operation, technical errors were made by subject SN on UAS question number 1 when the subject made a mistake in moving the variable from one step to the next and made a mistake in calculating the value of the arithmetic operation, technical errors were made by subject GA on question number 2 when the subject made a mistake in calculating the value of the integer multiplication operation and the decimal division operation, technical errors were made by subject GA on question number 6 when the subject made a mistake in calculating the value of the integer multiplication and subtraction operations, technical errors were made by subject RF when the subject made a mistake in moving the constant and variable from step one to the next, technical errors were made by subject IKW on question number 3 when the subject made a mistake in calculating the integer division operation on the matrix equation material, technical errors were made by subject SN on question number 4 when the subject made a mistake in calculating the value of the addition and multiplication operations when finding the value of the matrix determinant and technical errors were made by subjects GA and IKW on question number 5 when the subject was not careful when substituting the known constant in the question into the solution to the question. This is in line with the opinion of Mauliandri & Kartini, (2020) who said that technical errors occur when there is an error in determining the value of an arithmetic operation, an error in writing, namely a constant or variable that is missed or an error in moving a constant or variable from one step to the next and an incorrect substitution of the value into the variable.

4. CONCLUSION

Based on the results of the study, it can be concluded that there are 3 types of student errors found in completing the odd semester UAS questions for the 2022/2023 academic year for class XI Nursing at SMK Kesehatan Indonesia Jaya Parigi, which are in accordance with the Kastolan criteria, namely conceptual errors, procedural errors and technical errors. When completing UAS questions, conceptual errors are the most dominant errors made by Mathematics UAS participants, then technical errors are also often made by students and then procedural errors.

The main cause of errors made by UAS participants is not understanding the questions well, the mastery of concepts in the Matrix, Linear Programs and Transformation Geometry materials is still lacking, rarely practicing re-working on example questions, students only read and memorize example questions, the lack of understanding of basic knowledge, namely integer arithmetic operations, is one of the factors causing errors that are often made by students.

5. SUGGESTION

Suggestions that researchers can provide to reduce or minimize student errors in quadratic equation material are:

1. Mistakes made by students when working on final exam mathematics questions in class XI Nursing at SMK Kesehatan Indonesia Jaya Parigi can be minimized by paying attention to each material, especially paying more attention to material that is considered difficult by students, such as matrix material.
2. Teachers should get students used to practicing a lot of questions and not just reading sample questions and deepen students' understanding of all UAS materials.
3. Students should be more careful and practice more on questions, they should have a better grasp of the concepts, because the mistakes that are often made when working on UAS questions are due to a lack of understanding of the concepts in each material and a lack of care when answering questions.
4. For prospective teacher students, they should study more deeply about matters related to learning, especially learning models and evaluations, so that they can minimize errors that may occur in students.

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