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ANALYSIS OF STUDENT ERRORS IN SOLVING ALGEBRAIC FUNCTION DERIVATIVE PROBLEMS ACCORDING TO WATSON'S THEORY: A CASE STUDY IN CLASS XI OF YAYASAN ATIKAN SUNDA HIGH SCHOOL BANDUNG

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ABSTRACT

This research aims to analyze the errors made by class XI students in solving algebraic function derivative problems, using a qualitative approach based on Watson's theory. This research was conducted at the Atikan Sunda Foundation High School in Bandung for the 2021/2022 academic year involving 3 students who showed difficulty in understanding the material on derivatives of algebraic functions. Sampling was carried out by purposive sampling. Research methods include analytical tests, interviews, and observations to identify and classify types of errors and explore the factors that influence these errors. The research results showed that the factors that influence student errors based on Watson's theory are that student errors in the od category obtained an error percentage of 3.33%, ip of 6.67%, od of 10%, oc of 16.67%, Rlc of 10%, um of 0%, Shp of 26.67% and Ao of 13.33%. This means that students still often make the most mistakes in the shp category at 26.67%, namely students often make mistakes regarding skill hierarchy problems. So it can be concluded that to reduce student errors in the Shp category, there is a need for appropriate methods in the classroom learning process.

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1. INTRODUCTION

Mathematics is a scientific discipline that has an important role in everyday life and in the development of science and technology. Mathematics does not just deal with numbers and formulas, but also involves logical thinking, problem solving, and abstract reasoning that can be applied in various areas of life. Nowadays, based on the independent curriculum, mathematics learning is divided into 5 elements, including numbers, algebra, measurement, geometry and data analysis and probability. One element that often gets attention is ajabra with material on derivatives of algebraic functions. To be able to master the material on derived mathematical functions of course requires strong and in-depth understanding skills. A deep understanding of the concept of derivatives of algebraic functions is an essential skill that must be mastered by high school students, especially those in class XI. Derivatives serve as an important basis in advanced mathematics and applications in various scientific fields such as physics, economics, and engineering. However, research shows that many students have difficulty understanding this concept, which is often reflected in the errors they make when solving problems. Wijaya et al. (2014) emphasized that students' errors in mathematics are often caused by a lack of conceptual and procedural understanding, as well as an inability to connect relevant concepts. These kinds of errors indicate that students not only face challenges in understanding concepts, but also in applying correct procedures in different contexts.

Identification of these errors is very important because it gives teachers insight to develop learning strategies that are more effective and appropriate to students' needs. According to Fuad and Azizah (2022), to find out where students' mistakes are in solving problems, it is necessary to analyze student errors in mathematics problems. In addition, Napitupulu et al. (2016) show that by analyzing student errors, teachers can better understand students' thinking patterns and identify areas that require further improvement. Identifying problems more quickly can speed up the reduction of errors made by students. There are several theories that propose techniques for finding out the mistakes students make in answering math questions. One of them is according to Watson's theory.

Watson's theory has been applied in various mathematics education research, providing a systematic framework for analyzing errors made by students. This theory helps in identifying and classifying errors based on their characteristics, so that teachers can provide more targeted interventions (Diana & Riyadi, 2021). Watson's theory states that there are 8

categories of student errors in answering questions, including: 1) Inappropriate Data (Id); 2) Inappropriate Procedures (Ip); 3) Missing Data (Ommited Data/Od); 4) missing conclusion (Ocmited conclusion/Oc); 5) Response Level Conflict (Rlc); 6) Indirect manipulation (Udirected Manipulation/Um); 7) Skills Hierarchy Problem (Skills Hierarchy Problem/Shp); and 8) Apart from the seven criteria above (Above Other/ Ao) (Usqo, Roza, Maimunah, 2022; Mafruhah & Muchydin, 2020; Nurwahid, 2021).

This research was conducted as a case study in class Through this analysis, it is hoped that deeper insight can be gained regarding common errors that arise, as well as effective strategies for overcoming them, which can ultimately improve the quality of mathematics learning.

2. METHOD

This research uses a qualitative method with a case study approach to analyze students' errors in solving algebraic function derivative problems based on Watson's Theory. This research was conducted on class XI students at the Atikan Sunda Foundation High School, Bandung, academic year 2021/2022. According to Sugiyono (2020: 416) states that by using qualitative methods research will be directed at naturalistic, inductive, interpretive, discovery and constructive characteristics. This means that research can be carried out naturally, understanding meaning, finding hypotheses and constructing phenomena. So it can be concluded that this research was designed with the aim of understanding the phenomenon in depth in a certain context, namely students' errors in solving algebraic function derivative problems. This design allows researchers to collect detailed data and identify specific error patterns.

The participants in this research were 28 class The selection of participants was carried out using purposive sampling, namely by selecting students who had demonstrated difficulties or errors in solving algebraic function derivative problems based on exam results or class assignments. Then, from 28 students, 3 students will be selected with high, medium and low ability categories. The main instrument in this research is the researcher himself as the key instrument, with the help of several supporting instruments, namely: 1) Test questions which include 7 questions on algebraic function derivatives prepared to identify errors made by students. 2) Semi-structured interviews were used to obtain further information regarding students' understanding of the concept of algebraic function

derivatives and the reasons behind the errors they made. 3) Documentation of student work results and notes during the learning process are used as additional data.

Data was collected through several techniques, namely written tests, interviews and observations. The most comprehensive test is questions on the derivatives of algebraic functions. The test results are then analyzed to identify the types of errors made. Meanwhile, interviews were conducted to validate students' answers to reveal their understanding of algebraic function derivatives and explain the reasons behind the mistakes they made in more depth. These interviews were recorded and later transcribed for further analysis. Meanwhile, observations are made during learning to understand how students interact with the material and how they try to solve problems.

Data analysis was carried out descriptively qualitatively using an error analysis approach based on Watson's Theory. Data analysis steps include: 1) Data from test results, interviews and observations are reduced to identify the main errors that arise; 2) Student errors are categorized based on the types of errors according to Watson's Theory, such as conceptual, procedural, and errors resulting from misconceptions; and 3) After the data is categorized, the researcher draws conclusions regarding the patterns of errors that occur, as well as the factors that contribute to these errors. This conclusion is then linked to relevant literature to provide a more comprehensive explanation. To ensure the validity of the data, several techniques were used, namely: 1) Researchers used source triangulation (tests, interviews, observations) and method triangulation (test analysis and interviews) to ensure consistency of findings; 2) The results of the initial analysis are discussed with participants to ensure that the researcher's interpretations match the participants' experiences and views; and 3) All steps in data collection and analysis are documented in detail to allow tracing back of the research process. This research was carried out in several stages which can be seen in Figure 1.

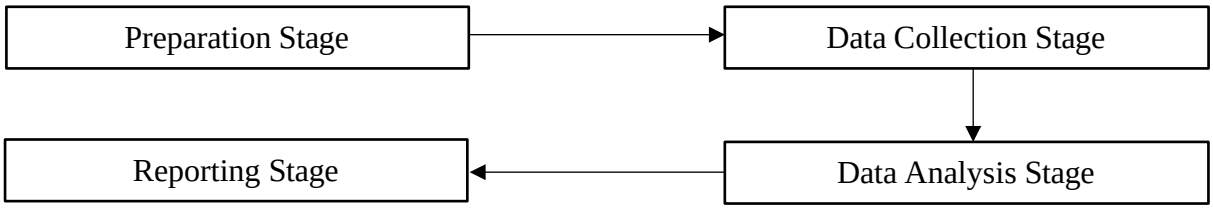

Figure 1. Flow diagram of research stages.

3. FINDINGS AND DISCUSSION

The results of this research are focused on finding types of errors in solving each algebraic function derivative problem based on Watson's theory error categories. The number of students who made errors and the types of errors in each question item are shown in table 1.

Table 1. Subject Errors

Subject	Question Number	Types of Student Errors Based on Watson's Criteria							
		Id	*Ip*	*Od*	*Oc*	*Rlc*	*Um*	*Shp*	*Ao*
S-4	1a	-	-	-	√	-	-	-	-
	1b	-	-	√	-	-	-	-	-
	2	-	√	-	-	-	-	-	-
	3	-	-	-	-	-	-	-	-
	4a	-	-	-	-	-	-	√	-
	4b	-	-	-	√	-	-	-	-
	4c	-	-	-	-	-	-	-	√
	4d	-	-	-	-	-	-	-	√
	5a	-	-	-	-	-	-	√	-
	5b	-	-	-	-	-	-	√	-
S-2	1a	-	-	-	-	√	-	-	-
	1b	-	-	-	-	-	-	√	-
	2	-	√	-	-	-	-	-	-
	3	-	-	-	-	-	-	-	-
	4a	-	-	√	-	-	-	-	-
	4b	-	-	-	√	-	-	-	-
	4c	-	-	√	-	-	-	-	-
	4d	-	-	-	-	-	-	-	√
	5a	-	-	-	-	-	-	√	-
	5b	-	-	-	-	-	-	-	-
S-10	1a	√	-	-	-	√	-	-	-
	1b	-	-	-	-	-	-	√	-
	2	-	-	-	-	-	-	-	-

Next, we will describe the analysis of student answer errors in the algebraic function derivative material.

3.1 Student Answer Error with incomplete data type (Inappropriate Data/ID)

Based on the results of the analysis of students' answers to the algebraic function derivative questions, it was found that the type of student error with incomplete data (Id) was shown in question number 5b with an error percentage of 3.33%. The following is a description of student answers with inappropriate ID error types which can be seen in Figure 2.

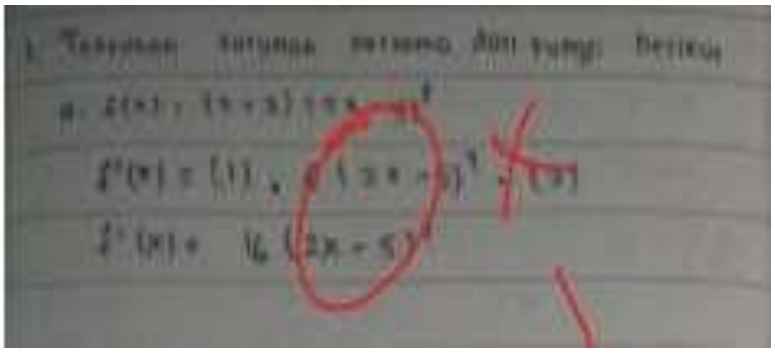

Figure 2. Answers with inappropriate errors (id)

From the results of students' answers to number 5b, students were able to answer but did not write down the data completely. Based on the question given which is the derivative of a multiplicative function $f(x) = u.v$, students should write down the data for the examples of

u, v, u' *and* v'. . This is confirmed by the results of interviews, that students forget the properties of algebraic function derivatives and skip the example stage because they were previously written in sketches but have not yet had time to rewrite them on the answer sheet.

3.2 Student Answer Error with incomplete data type (Inappropriate Data/ID)

Based on the results of the analysis of students' answers to the algebraic function derivative questions, it was found that the type of student error with incomplete data (Id) was shown in question number 5b with an error percentage of 3.33%. The following is a description of student answers with inappropriate ID error types which can be seen in Figure 3:

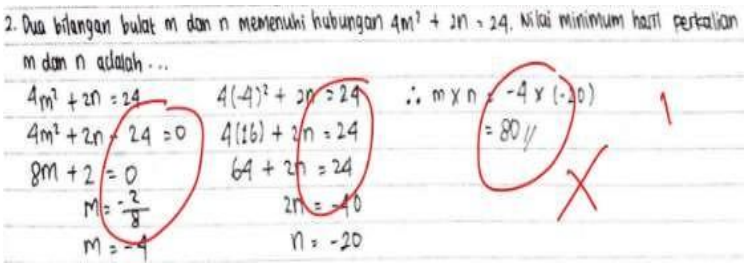

Figure 3. Answers with inappropriate errors (id)

From the results of the students' answers shown in Figure 3, students are less proficient in solving problems and solving problems does not comply with procedures. This is confirmed by the results of interviews, that students understand the questions given, but there is confusion when solving them. Students find it difficult to find new functions from the multiplication results m.n. The first step should be for students to make variables into just one variable. For example, $4m2 + 2n = 24$ becomes $n = (24-4m2)/2 = 12 - 2m2$. So the n value obtained can be substituted into the multiplication function m.n to find a new function.

3.3 Errors with missing data category (Omitted Data/Od)

Based on the results of the analysis of students' answers to the algebraic function derivative question, it was found that the type of student error with missing data (Od) was shown in question number 4a with an error percentage of 10%. The following is a description of students' answers with the type of Od error which can be seen in Figure 4:

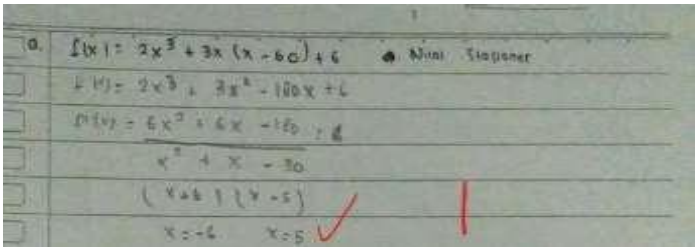

Figure 4. Answers with Omitted Data/Od Error

From the results of the students' answers shown in Figure 4, students did not complete the questions until they were finished. This was then reinforced by the interview results that students had difficulty completing the next step.

3.4 Errors with missing conclusion category (Omitted Conclusion/Oc)

Based on the results of the analysis of students' answers to the algebraic function derivative question, it was found that the type of student error in not giving a conclusion (Oc) was shown in question number 4b with an error percentage of 16.67%. The following is a description of student answers with types of OC errors which can be seen in Figure 5:

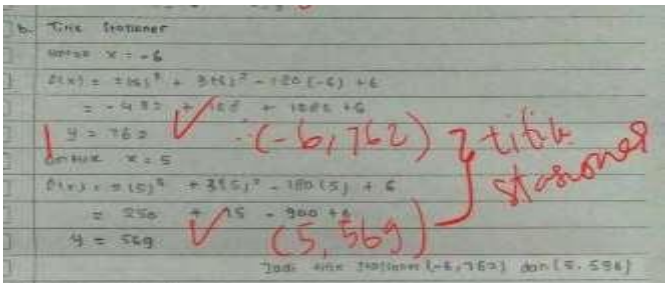

Figure 5. Answers with Omitted Errors Conclusion/Oc

From the results of the students' answers shown in Figure 5, it was found that students were able to work on the questions but did not write conclusions. This is reinforced by the results of interviews, that students forget not to write conclusions.

3.5 Errors with the Response Level Conflict (Rlc) category

Based on the results of the analysis of students' answers to the algebraic function derivative questions, it was found that the type of student error with response level conflict (Rlc) was shown in question number 4c with an error percentage of 10%. The following is a description of students' answers with the type of RLC error which can be seen in Figure 6:

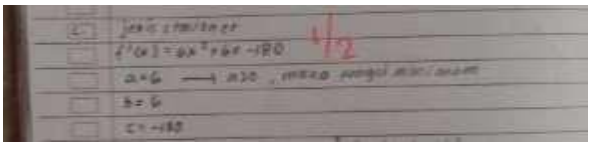

Figure 6. Answers with Error Response Level Conflict/Rlc

From the results of the students' answers shown in Figure 6, students immediately conclude their answers without giving or writing down the steps. This is confirmed by the results of interviews, that students have difficulty and forget what formula to use to solve the problem.

3.6 Errors in the Indirect Manipulation Category (Undiect Manipulation/um)

In indirect manipulation errors, students do not make mistakes. This is in line with the opinion of Musa and Yuliana (2021) where students do not make mistakes in the type of indirect manipulation.

3.7 Errors with Skills Hierarchy Problem (Shp) Category

Based on the results of the analysis of students' answers to the algebraic function derivative problem, it was found that the type of student error with the skill hierarchy problem (Shp) was shown in question number 5a with an error percentage of 26.67%. The following is a description of students' answers with the types of Shp errors which can be seen in Figure 7:

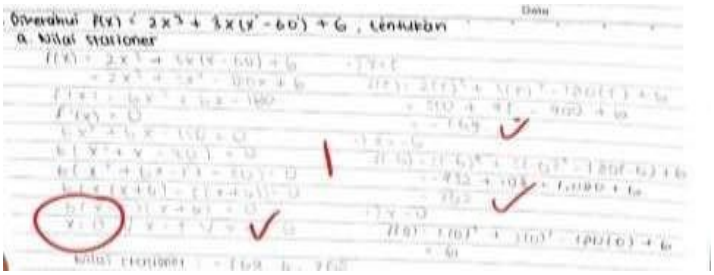

Figure 7. Answers with Skills Hierarchy Problem/Shp Errors

From the results of the students' answers shown in Figure 7, it was found that students were able to understand the problem, but there were errors in the calculation process which resulted in inaccurate answers. This was confirmed by the results of the interview, students felt confident with their answers and students were able to explain their answers fluently, but students only realized that there was an error in the calculations.

3.8 Errors other than the seven criteria above (above other/Ao)

Based on the results of the analysis of students' answers to the algebraic function derivative question, it was found that the type of student error other than the seven criteria above (Ao) was shown in question number 4d with an error percentage of 13.33%. The following is a description of students' answers with type Ao errors which can be seen in Figure 8.

Figure 8. Answers with Errors Above Other/Ao

From the results of the students' answers shown in Figure 8, students do not understand how to solve the questions. This is reinforced by the results of interviews, that

students are still confused about drawing graphs of polynomial functions using algebraic function derivatives

4. CONCLUSION

Based on the analysis and explanation of the research results, it can be concluded that students' answer errors in the material on deriving algebraic functions based on Watson's theory were obtained by errors in od, oc, Rlc, Shp and Ao with error percentages above 9%. If summarized in detail, student errors in the od category obtained an error percentage of 3.33%, ip of 6.67%, od of 10%, oc of 16.67%, Rlc of 10%, um of 0%, Shp of 26.67% and Ao at 13.33%. This means that students still often make the most mistakes in the shp category at 26.67%, namely students often make mistakes regarding the hierarchy of skills.

5. AUTHOR'S NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. Authors confirmed that the paper was free of plagiarism.

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