Students justification in solving applied algebraic derivative functions

by Habibi Negara

Students Justification in Solving Applied Algebraic Derivative Functions

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Abstract. This study aims to obtain propositions related to the types and factors that affect students' justification in solving mathematical problems in the application material of algebraic function derivatives. The participants involved were 25 students. The research instrument was a test of the ability the application of algebraic function derivatives and semi-structured interview guidelines. This research is a qualitative type with a systematic grounded theory (GT) procedure design. Because this research is GT, the data were analyzed using three stages of open coding, axial coding, and selective coding with the help of the NVivo 12 plus software. The reliability test was carried out by two coders to test categories, and sub-categories with Cohen's kappa value ≥ 0.65, so the coding was made reliable. In-depth interviews were conducted until saturated data were obtained. From the results of the analysis, there are propositions of students 'justification in solving problems related to five types, and three factors that affect students' justification in solving problems with derivative applications of algebraic functions including learning culture, learning resources, and classroom learning.

INTRODUCTION

Justification is an important activity in mathematics, where justification allows students and teachers to see the development of mathematical understanding [1]. NCTM (2000), emphasizes the importance of justification, to be done in mathematics learning, and it must be implemented at all levels of education [2]. Learning mathematics that supports students' justification is a challenging thing. When students justify, students use the knowledge and reasoning they have to connect ideas in understanding new things.

Justification is an activity that is closely related to mathematics. Justification is the process of proving the truth of a statement by giving reasons, which are based on definitions, theorems, or lemmas that have been proven before [3], [4]. Justification is the act of providing a basis for evidence, or arguments to convince others that a claim is true [5]. Furthermore, justification is stated as an argument that demonstrates the truth of a claim by using a previously accepted statement. Justifying means providing self-explanatory reasoning [6]. Student involvement in the justification process in the mathematics learning process can help students improve their communication skills and academic achievement [7]–[9].

Although many justifications have been carried out by research in a pure mathematics environment (mathematicians), it is also important to express justification in the process of learning mathematics in schools. [4]. The role of justification in the learning process of mathematics can build mathematical skills covering at least three aspects, namely mathematical reasoning, deep understanding of mathematical concepts, and mathematical communication [7], [10], [11]. Several previous research findings show the importance of justification in learning, including improving logical thinking skills, describing students' thoughts, and explaining why a statement is true [7], [12]–[16].

However, in previous studies, the types and justification factors used by students in solving mathematical problems in the application material of algebraic function derivatives have not been found. To reveal the process types and factors justification of students in solving problems of derivative application of algebraic functions, it is necessary to conduct grounded theory (GT) systematic procedure research [17], to obtain propositions related to types, and what factors affect students' justification in solving mathematical problems in the application material of algebraic function derivatives

RESEARCH METHOD

The questions in this study require a qualitative research design, with a grounded theory (GT) design of systematics procedures [17], [18]. The design of the GT is used to build substantive theories concerning research questions related to what factors affect students' justification in solving mathematical problems on application material derived from algebraic functions. Participants involved in this study were 25 students of class XI Senior High School (SHS). Four test questions that capture essential concepts in the application material for the derivative of algebraic functions are given. The test questions have been validated by experts, and are suitable for use to capture students' understanding of the application material for the derivatives of algebraic functions. After the test questions are given, the next step is to conduct interviews until saturated data is obtained. Furthermore, because this research is a qualitative type with a grounded theory (GT) design with systematic procedures, the data is analyzed using three stages of open coding, axial coding and selective coding with the help of the NVivo 12 plus software. To avoid bias in this study, the reliability test was used by involving two coders (MT, and MI) outside of this research project. The results of the reliability test obtained Cohen's kappa value ≥ 0.65, so the themes, categories, and sub-categories obtained in building propositions can be counted on [18], [19].

RESULTS AND DISCUSSION

Because the purpose of this study is to obtain propositions related to the types and factors that affect the students' justification in solving mathematical problems in the application material of algebraic function derivatives, the stages of this GT research process include three stages: (1) open coding, (2) axial coding, and (3) selective coding. (1) open coding: in the open coding stage, the researcher gives a code to each participant's answer related to ideas or ideas in solving problems in the application of algebraic function derivatives, test result data, and interview data. The following is presented one of the test questions for the application of algebraic function derivative applications.

Given a curve whose equation is $y = x^2 - 4$

a. Determine the equation of the tangent to the y curve passing through the point with notices 5 which lies on the curve.

b. Based on the answer a, sketch the graph of the curve y=x^2-4 along with the equation of the tangent.

The following is an excerpt of an interview with three participants X, Y, and Z.

In your opinion, to solve the problems above question a and question b, what concepts (formulas) were used? (Kategori-1: Assumption).

Participant X: In my opinion, solving the problem can use the concept of quadratic functions, the concept of derivatives, and the concept of tangent or straight-line equations.

Participant Y: In my opinion, by substituting the x value to find the slope of the tangent equation.

Participant Z: In my opinion, the first uses the derivative definition formula, and the second uses the straight-line equation formula.

In your opinion, what steps should be taken first in answering the questions in part a and part b? (Kategori-2: Vague/broad statement).

Participant X: I use the concept of the first derivative, determine the abscissa (x) value, then find the slope value, substitute the abscissa value, to determine the straight-line equation. The final step is to sketch the graph, then determine whether the function is up or down.

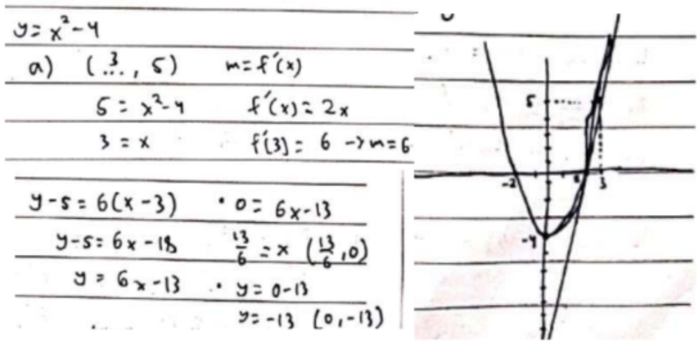

FIGURE 1. One example answer participant X.

Participant Y: the first derivative, sketching the graph, completely.

Participant Z: Look for the abscissa, then find the gradient using the derived function. Then look for the tangent equation. and sketch a graph of y, and tangent equations.

Participant Y: the first derivative, sketching the graph, completely.

Participant Z: Look for the abscissa, then find the gradient using the derived function. Then look for the tangent equation. and sketch a graph of y, and tangent equations.

Based on your answer, how do you analyze the graph of the curve, along with the equations of the tangents? (Kategori-3: Rule).

Participant X: The curve has a minimum point at (0, -4), and opens upward (a> 0). The point of tangency of the graph at point (-3,6) is negative, so the line is decreasing.

Participant Y: The graph of the curve function with the tangent equation is y = 6x -13, then the slope value is positive (6) and will skew to the right, the graph of the function is up.

Participant Z: smiley curve shape like the letter (U) with a minimum turning point, function descending at x <0, and rising at x> 0, the stationary point at 0 is the minimum turning point.

Why can the first derivative of a function be viewed as the rate of change? Explain your opinion! (Kategori-4: Procedural description).

Participant X: because usually in physics the position function is reduced once to a function of velocity, the first derivative is seen as the rate of change.

Participant Y: because the derivative comes from delta y / delta x, this concept is originally from a linear graph, that is, the first derivative (gradient), this gradient is expressed in delta y / delta x, this delta means change. Why is the rate? Since this is the effect of one variable on another, the distance (gradient) example is reduced with time to m / s (velocity).

Participant Z: the first derivative of a function can be viewed as the rate of change because the derivative is defined as the slope or slope of a tangent or tangent to a point in a function. The gradient shows the rate of change from the function to the variable. Therefore, the first derivative representing the gradient can be interpreted as the rate of change.

From question no 2 above, what do you think the meaning of f'(3) =6 and f'(- 3) =- 6 (Kategori-5 Own explanation).

Participant X: the first derivative of the y-curve equation will produce a new formula. When the abscissa points x = 3 are entered in the first derivative formula, the ordinate value y = 6. Whereas when the abscissa points x = -3 is entered in the first derivative formula, the ordinate value y = -6. But another understanding of this is, the formula for the first derivative of the y curve equation is the gradient formula. So that if you enter the abscissa point (x) in the gradient formula, you will get the gradient from the tangent equation to be looked for.

Participant Y: if x = 3 then f 'is 6 (positive value), if x = -3 then f' is -6 (negative value). If the value of x is positive then the first derivative will always be positive, whereas if the value of x is negative then the first derivative will always be negative

Participant Z: for the value of the function f '(- 3) =- 6, the graph decreases while, for the value of the function f' (3)=6 the graph goes up.

From the interview excerpt data above, and the participants' written test answers. During the open coding process, the researcher performs constant comparisons simultaneously which involves constant interaction between the researcher and the data, and the theory is developing [20]. Furthermore, the newly collected data continues to be compared with previously collected data [21]. The results of constant comparisons between data and data, coding with data, coding with coding, coding by sub-categories, sub-categories with sub-categories, categories with sub-categories, categories with themes, obtained 11 identical sub-categories that still need to be reduced. for example, derived concept, substitution, tangent gradient, first derivative = gradient, positive and negative graphs. The data were analyzed with the help of the NVivo 12 Plus software, to obtain an open coding diagram in Fig. 2 below:

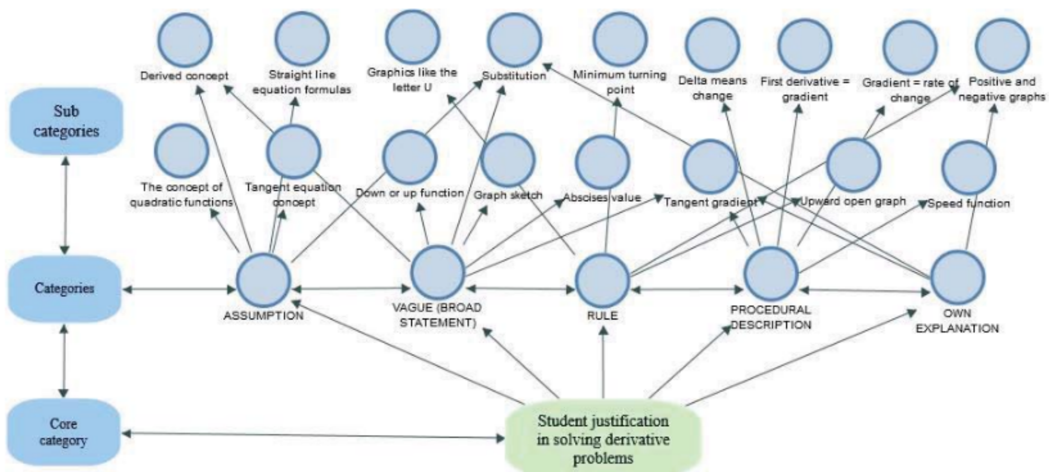

FIGURE 2. The open coding process

From the results of the open coding analysis shown in Fig. 2 above, there are 17 sub-strategies, and 5 types of student justification categories in solving application problems of algebraic function derivatives which include assumption, vague, rule, procedural description, and own explanation. Next, the axial coding process.

2. Axial coding: furthermore, the GT researcher selects one category, and places it as a central phenomenon that is being studied, in this case, the student's justification for the application material of the derivative of algebraic functions, and then relates other categories to it (causal conditions), as shown in (see Fig. 3).

By paying attention to the axial coding diagram in Figure 3 above from left to right, we can look at the six category boxes obtained in the study including (1) causal conditions are those that affect the core category in this respect: assumption, vague, rule, procedural description, and own explanation. All of these causal categories affect the core / central phenomena regarding the ability of students to justify the application of derived functions. (2) The core category / central phenomenon in terms of students' justification, (3) Strategy is an action that arises from the core phenomena in this study including the concept of quadratic functions, derived concepts, tangent equation concept, straight-line equation formulas, substitution, down or up function, graph sketch, positive and negative gradient, upward open graph, first derivative = gradient. All of these concepts emerge. When students do justification, (4) Context is a special condition that affects the strategy when students do justification: (a) learning culture, (b) learning resources, and (c) classroom learning. (5) The conditions for intervening general conditions that affect the strategy in this study include: (a) Get used to giving non-routine questions, (b) the cleavage process is not result-oriented, and (c) supportive teachers. (6) the consequences are the things that arise from the strategy in this study, participants justify the derivative application material through assumption, vague (broad statement), rules, procedural descriptions, own explanation. The next stage is followed by selective coding.

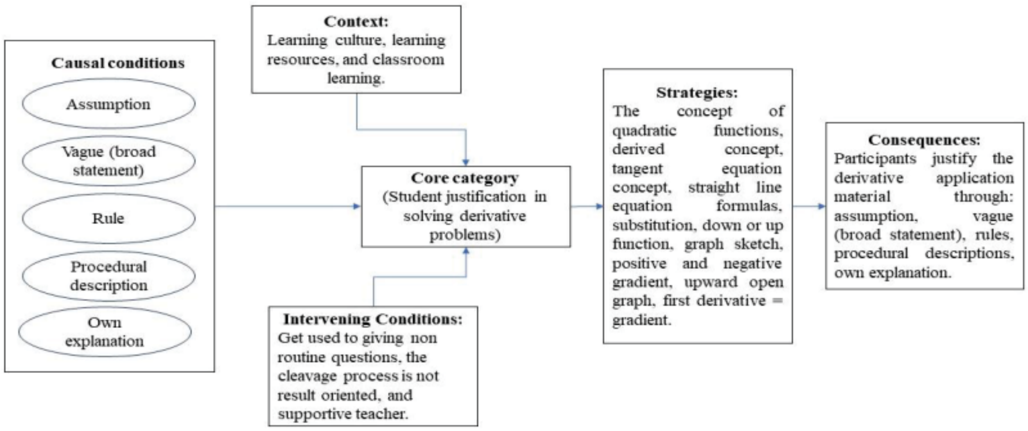

FIGURE 3. Selective coding process

3. Selective coding: in this stage of selective coding, the researcher writes a substantive theory that is interrelated between the categories in the axial coding model and traces personal memos about participants' ideas found along the course of the research. The selective coding diagram is shown in Fig. 4 below.

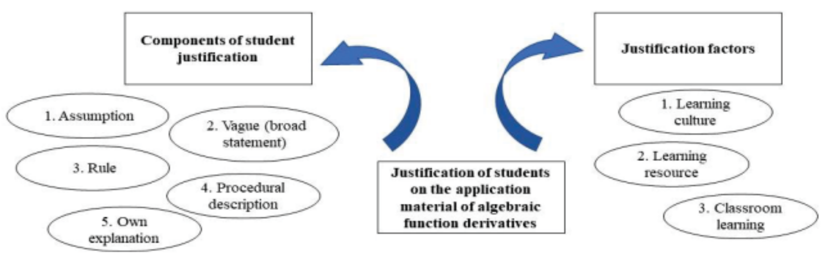

FIGURE 4. Selective coding process

Through the stages of the open coding process, axial coding, selective coding, and theoretical saturation tests, it was confirmed that the type of student justification in completing the application material for the derivative of algebraic functions in this study was a theoretical saturation model. According to the model, propositions related to the types and factors that influence students' justification are obtained. There are hypothetical conferences regarding the types of justification (see Fig. 4) in solving mathematical problems in the application material for the derivative of algebraic functions as follows:

1. If the participants make assumptions in solving the problem, then the student's type of justification is the

assumption.

2. If the participants solve the problem very concisely and are not very informative, then the student's type of justification is vague.
3. If participants solve the problem by giving reasons accompanied by rules and definitions, the student's type of justification is a rule.
4. If participants solve the problem step by step accompanied by reasons, then the student's type of justification is the procedural description.
5. If participants solve the problem by giving arguments in their language, then the student's type of justification is own explanation

Meanwhile, the factors that influence the type of student justification in solving mathematical problems in the application material of algebraic function derivatives include learning culture, learning resources, and classroom learning. Teacher autonomy is one of the factors justifying students in shaping a learning culture in the classroom [20]. Teacher autonomy as the capacity, freedom, and responsibility to make choices about their teaching, three aspects of teacher autonomy in the classroom context (a) implementing the curriculum, (b) choosing learning content and learning activities, and (c) managing teaching and assessment methods. The next factor that affects students' justification is the source of learning, the main source of student learning in textbooks [21], [22]. In Indonesia, textbooks are very diverse that can be chosen by students in learning, but it becomes a problem too, how do students choose textbooks that are suitable for consumption by students, for example, mathematics textbooks, school students' handbooks, are the questions, and the concepts given in the book support students 'reasoning processes, which will stimulate students' thinking patterns or vice versa. Several textbooks have been assessed as feasible by the National Education Standards Agency (BSNP). There are still mistakes, this will have an impact on students' problem-solving abilities in justifying [23]. Furthermore, the student justification factor is classroom learning [20], learning that is carried out in class is based on the final result, as a result, students do not know much about unique problem-solving strategies. Students are not usually given non-routine questions that challenge students to think so that students are not used to doing good justification.

CONCLUSION

The findings in this study are expected to help educational practitioners in justifying students in solving problems with the derivative application of algebraic functions, by paying attention to seve6 types and factors of student justification. There are five types of student justification in solving problems; vague, rule, procedural description, and own explanation. Besides that, it was also found that three factors influenced the students' justification in learning mathematics in the application material of derivative functions which included; (1) learning culture, student learning culture can be seen in the process of solving the given questions, students imitate their teacher's answers, meaning that students learn by memorizing. (2) Learning sources, learning resources used by students are textbooks, textbooks in circulation do not fully provide clear concepts, resulting in incorrect student justifications. (3) In-class learning, students are not accustomed to solving non-routine questions, so that students do not know how to do justification well. This research is limited to just the application material of algebraic function derivatives, further research is to do just about the content of textbooks consumed by students, where there is still a lot of wrong material, which results in the students' justification being inaccurate.

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