Error analysis of mathematics teacher in solving calculus problem

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Abstract. Mathematics in senior high school has many subjects. One of them is calculus. In order to teach mathematics in senior high school, teacher must mastering calculus subject. But, even mathematics teacher find that calculus is a difficult topics to master and to teach. It was showed by mathematics teachers’ answer sheet where there were many mistakes. The aim of this study was to analysis mathematics teachers’ error in solving calculus problem. Type of research was descriptive qualitative. Sampling technique used purposive sampling. Sample was 31 mathematics teachers in Padang Pariaman. Instrument was teachers’ answer test. Result shows that teachers have different type of error, such as conceptual, factual and procedural error.

1. Introduction
Mathematics is a language in science field. It is called like that because mathematics was used in many field of science, such as biology, physic and chemistry. Mathematics also has been used in other field such as psychology, social science, engineering, etc. The application of mathematics in biology field, for examples are using mathematics theory to exam the biological phenomena, analyses it and to make conclusion from it. The application of mathematics in physics field, for examples are velocity, distances and acceleration. In chemistry field, it can be used to make mathematical model of chemical phenomena and solve the problem. In psychology, the application of mathematics is in form psychometrics. It uses mathematics to measure individual’s mental ability and to know individual’s behavior style. The using of mathematics concepts in many field and daily life makes mathematics as fundamental theory and it must be mastered. It makes mathematics as a must subject to learn in each education, from kinder garden, primary school, junior high school, senior high school and until college.

Mathematics has many concepts and topics that has been using in many field. One of them is calculus. Calculus is one of fundamental theory in many fields in science. For instance, the derivative concept is used in physic to know the velocity and acceleration of particles. It is also has been used in biology to know the rate of bacteria’ expansion and so on. The importance of calculus make it a must subject of mathematics. It has been introduced from primary school and it must be mastered by students. In order students to understand and master calculus concepts, mathematics teachers has important role in calculus. Mathematics teachers must master calculus concepts, make learning preparation and teach calculus concepts to students. If mathematics teachers in this role, it will make students do not understand the concepts of calculus and it will make them difficult to understand other subject which use calculus as its fundamental theories. The consequence of it can be seen in higher education when students become college students.
In higher education, calculus has been learned by many college students, not only mathematics major but also other major, such as engineering, biology, physics and chemistry [1]. They must study calculus as well as mathematics’ students. They are not only must master calculus concepts but also master calculus application in their major and daily life. So, in order that students can pass calculus course, students must have good basic calculus concepts. Basic calculus concepts were given in senior high school. It was learned as part of many mathematics topics.

So, in order to get basic calculus concepts in calculus, mathematics teachers must have good competency in calculus topic. Before increase the competency of mathematics teachers, it must have known teachers’ weakness in calculus concept. One of method to know it is by doing error analysis. This method can show how far teacher understand calculus concepts and in what concepts that teachers do not understand and make mistake or misconception.

Error analysis of teachers’ answer sheet can be done by using Tyler error analysis. Tyler’s error analysis describes teachers’ error in four aspects, such as: conceptual error, factual error, procedural error and carelessness error [2]. Many learning has been using error analysis to evaluate learning results [3-8]. Result of this analysis can be used to know the weakness of teachers so it can be reference to find the solutions in order to increase teachers’ calculus competency.

2. Method
The method was descriptive research by using Tyler’s error analysis. Samples of research were 31 mathematics teachers in Padang Pariaman. Sampling used purposive sampling. Instrument was teachers’ answer sheet test.

The questions of test were essay of standard calculus problem and teachers must answer it on answer sheet which had been prepared. Teachers must answer the question on available answer sheet. The problem solving must showed mathematics procedure step by step using calculus concepts.

Teachers’ error was analyzed by using qualitative approach and it could be classified in to four categories below.

2.1. Conceptual errors
This type of error happens because teachers have misconception in mathematics. They have poor understanding of concepts and procedure in mathematics problem solving. This errors could happens because teachers do not understand the vocabulary that is used in problem.

2.2. Factual errors
They are mistakes that teachers make when they have difficulty to remember the fact that must be required problem solving. Factual errors can be happen because teachers have not mastered basic facts of calculus. It may be due to memory deficits, impulsivity or visual-motor integration problem.

2.3. Procedural errors
The third errors happen when teachers have not followed the correct steps (or procedures) to solve the problem.

2.4. Carelessness errors
The mistakes happen when teachers have poor attention to the problem, such as did not read the guideline in answering and so on. The mistakes have no patterns and happen sometimes, not often.

3. Result and discussion
Data is got from teachers’ answer sheet and it is analyzed by Tyler’s error analysis. The analyzing were presented below.

3.1. Analysis of conceptual errors
Integral is an anti-derivative. There are many methods to solve integral problem. The method is used based on integral form. The method to solve integral problem is called as integration technique. Each problem has its own integration technique. There is always mistake in using integration technique. The mistake is happened to mathematics teacher too, as seen in the figure below.

![Figure 1. Conceptual errors in teacher’s answer sheet.](image)

Figure 1 showed that, in the problem, there was integral problem and to solve it is using substitution method. But, teacher had conceptual error. Instead of using substitution method, teacher used integral partial method. So, teacher cannot answer the problem correctly.

3.2. Analysis of factual errors
The second error were analyzed is factual errors. Teachers were given an inequality problem. The procedure to solve that problem is cause inequality fractions problem with the denominator \(x\). In order to get solution set, denominator \(x\) is not zero number. But, teacher seemed forget that fact and made mistake as seen in the figure below.

![Figure 2. Factual errors in teacher’s answer sheet](image)
In the answer that was showed by Figure 2, teacher included zero number as one of solution set elements. Even though, if \( x = 0 \), there were no identified. So, teacher made factual error by ignoring denominator is not appropriate as zero number.

3.3. Analysis of procedural errors

Another mistake made by teacher was procedural error. Teachers were given inequality problem and asked to solve it. It needed mathematics procedure to solve it. But, there was teacher who make mistake in mathematics procedure as show in figure below.

![Figure 3. Procedural errors in teacher’ answer sheet](image)

Figure 3 show that teacher made mistake in solving inequality problem. Teacher seemed multiply the left side by \( x \) but teacher did not do the same thing in the right side. It made the procedure become wrong and teacher cannot answer the problem correctly. It also showed that teacher had procedural error.

3.4. Analysis of carelessness errors

After analyzing all of teachers’ answer sheet, there were no carelessness errors. It showed that teachers tried to answer the problem with good attention and with full responsibilities. They did their best with all of mathematics knowledge that they had.

4. Conclusion

The analysis by using Tyler’s Error Analysis shows that teachers have errors in: (1) conceptual errors; (2) factual errors and (3) procedural errors. It is shows that teachers need to increase their professional competency in mathematics subject.

References

[1] Vinsonhaler R 2016 Teaching calculus with infinesimals *J. Humanistics Mathematics* (vol 6) pp 240-276
[2] Riccomini P J, Witzel B S 2010 Response to intervention in math *Corwin Press*
[3] Riastuti N, Mardiyana M, Pramudia I 2017 Students’ error in geometry viewed from spatial intelligent *IOP Conf. Series: Journal of Physics: Conf. Series* 895 (2017) 012029
[4] Junaedi I et all 2015 Disclose cause of students error in resolving discrete mathematics problem based on NEA as a means of enhancing creativity *International Journal of Education* (vol 7) pp 31-42
[5] Herold J F 2014 A cognitive analysis of students’ activity : an example in mathematics *Australian Journal of Teacher Education* (vol 39) pp 137-158
[6] Sumule et al 2018 Error analysis of Indonesia junior high school students in solving space and shape content PISA problem *IOP Conf. Series: Journal of Physics: Conf. Series* 947(2018) 012053
[7] Vale P, Murray S & Brown B 2012 Mathematical literacy examination items and student errors: an analysis of English second language students’ response 28 (2) pp 65-83

[8] Wijaya A et al 2014 Difficulties in solving context-based PISA mathematics task: an analysis of students’ errors The Mathematics Enthusiast vol 1 pp 555-584