Analysis of Student Difficulty in Understanding the Roots of Nonlinear Equations

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Abstract. Mathematics is considered one of the hard lessons by some students, so needs to be analysed the difficulties faced by students as prospective teachers. This research aims to explore the problem of students mathematics study program in studying roots of nonlinear equation. The method used in this study was descriptive of the skin. The instrument was used in the form of a tertius test in the form of multiple choices consisting of 5 questions. The results showed that 68 students obtained an average score of 30.88; the highest value is 80, and the lowest value is 0. The results of the analysis of the answer are known that students still do not understand correctly the basic principles of iterative methods that have been studied, this is evident from the questions asked about the advantages and disadvantages of each iterative methods, as well as from fundamental questions about the basic principles for each iterative method that has been studied.

Keywords: Basic Principles of Iterative Methods, Student Difficulty Analysis.

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INTRODUCTION ~ Mathematics is one of the lessons given starting elementary school students. Nevertheless, many students consider that mathematics is difficult learning (Akhter, 2018). Many factors influence students' difficulty in learning mathematics, one of which is personality (Karimah et al., 2018). The existence of problems in learning mathematics is alleged as a result of the teacher's ability to present material. Therefore, it is necessary to analyse students' difficulties as prospective math teachers, one of which is in the roots of nonlinear equations.

To study the roots of nonlinear equations, students must have studied the material: (1) The determination of the roots interval (the interval containing the roots) by the graph method (single graph method and double graph method), and Descartes' rule which continued with the tabulation method specifically for non-linear function cases in the form of polynomial function; (2) Iterative methods (closed methods and open methods) are used to determine the value of the roots of nonlinear equations.

The first iterative method is referred to as the bracketing method because the roots to be approached are enclosed by an interval that contains the roots, and referred to as the closed method because it is always converging. The first numerical method developed to find the roots of the nonlinear equation $f(x) = 0$ was the bisection method (Thapliyal & Tomar, 2014). The false-position method is included in the bracketing method (Sutarno & Rachmatin, 2017).

The second iterative method is called the open method because it is not always convergent. The methods included in the available method are (1) Newton-Raphson method; (2) Secant method; and (3) Fixed-point iteration method (Sutarno & Rachmatin, 2017).

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METHOD

The method in this study is qualitative descriptive that aims to analyze the difficulty of students in studying the roots of nonlinear equations. Participants in this study were students of the mathematics study program numbering 68 people. The instrument given in the form of a written test in the form of multiple choices as many as 5 questions, and given in the form of google form. Questions given to students can be seen in figures 1 to 5. For the correct answer is given a score of 20, so the total score is 100.

To test the student's understanding or analysis of the difficulty of students regarding the material of the roots of this nonlinear equation, after the material in the chapter is completed, the research subjects are given a test consisting of five questions in the form of multiple choices. Research questions/instruments are created with *google form* so that the results can be directly evaluated easily. Questions for the material in the nonlinear equation roots chapter and the answers are then evaluated and analyzed by the author as a teacher. The results of descriptive analysis of student answers will be feedback for teachers, which will be useful for learning improvements.

RESULTS

Student results or scores have an average of 30.88 with a median score = 20, and the highest score of 80 obtained by one student (figure 1). From the results of this student acquisition shows the results of understanding that is still low enough for the roots nonlinear equations, so analyzing the difficulties of students will be very useful for the evaluation of learning that has been done by teachers.

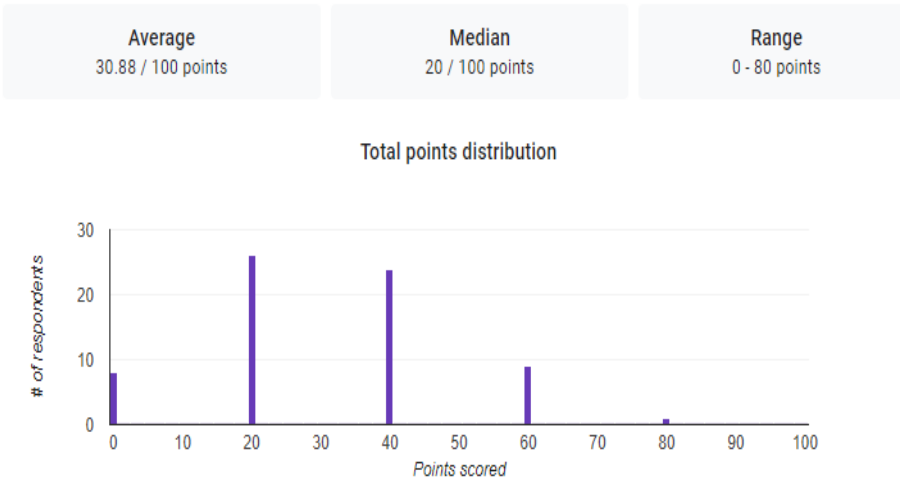

Figure 1. Student acquisition grades

Next, pay attention to the students' answers to the first question can be seen in figure 2 below.

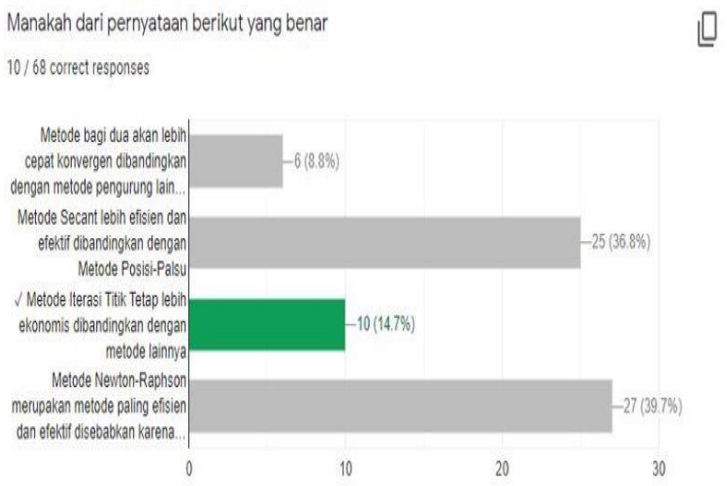

Figure 2: Student's answer to the first question

The concept asked in the first question is the advantages and disadvantages of each method that has been studied by students in the material of nonlinear equation roots. In the first question answered by 68 students, only 10 people answered the concept correctly.

The most answer chosen by students is the fourth answer: The Newton-Raphson method is the most efficient and effective method compared to other methods in determining the roots of non-linear equations. Actually the Newton-Raphson method is the most efficient method compared to other methods (Akram & Ann, 2015). However, this method is not the most effective, due to the nature of the Newton-Rahson method which is sensitive to the selected initial guess (Sutarno & Rachmatin, 2017).

The second answer that is also widely chosen is the secant method is more efficient and effective compared to the false-position method. Students who choose this answer are mistaken, because secant methods that include open methods will produce almost the same root and produce many of the same iterations as the false-position method. This has been shown in Ms.Excel-assisted practicums, so it is wrong to conclude that secant methods are more efficient and effective than false-position methods. It seems that the student is paying less attention during practicum/learning.

Students have misunderstood that the speed of the converged method for two is faster than the other method of confinement (the false-position method), because the false-position method is precisely made to accelerate the converge of the two-method. This has been elaborated by the teacher and this fallacy can be considered to be a student forgets the basic concept of the false-position method. Look at the answer to the following second question:

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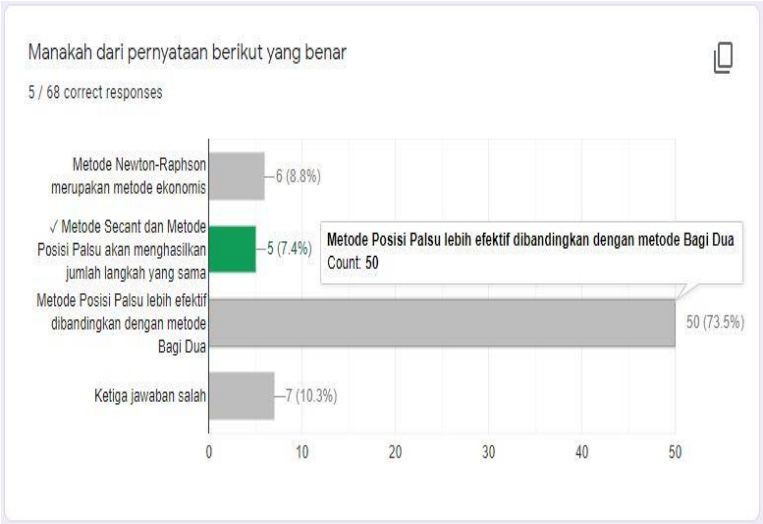

Figure 3: Student's answer to the second question

In the second question, 50 students or as many as 73.5% answered the false-position method more effectively than the bisection method. The false-position method cannot be called more effective than the two-method because both methods will converge, but more efficient than the two-part method is caused by faster convergence.

8.8% of students mistakenly answered the Newton-Raphson Method as an economical method. The Newton-Raphson method is not an economical method because the first derivative calculation for a given function is became an its own problems. The economical method among all the iterative methods that have been studied by students is the fixed-point iteration method, due to the simplicity of its program creation (Rajaraman, 1981). Consider the answer to the following third question:

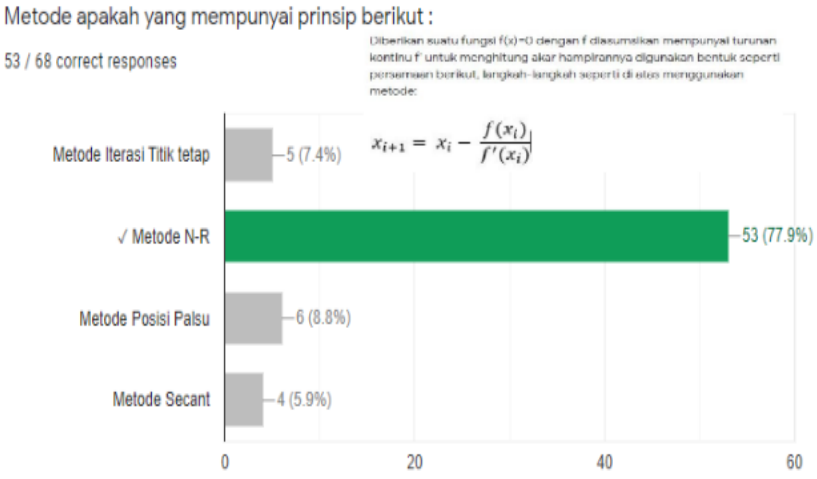

Figure 4: Student's answer to the third question

A total of 77.9% of students answered correctly, while 22.1% answered incorrectly. Students who mistakenly answer this question pay less attention

during learning because this formula has been studied and discussed by teachers when discussing the Newton-Raphson method. The formula does not appear in the discussion of other iterative methods.

Look at the answer to the following fourth question:

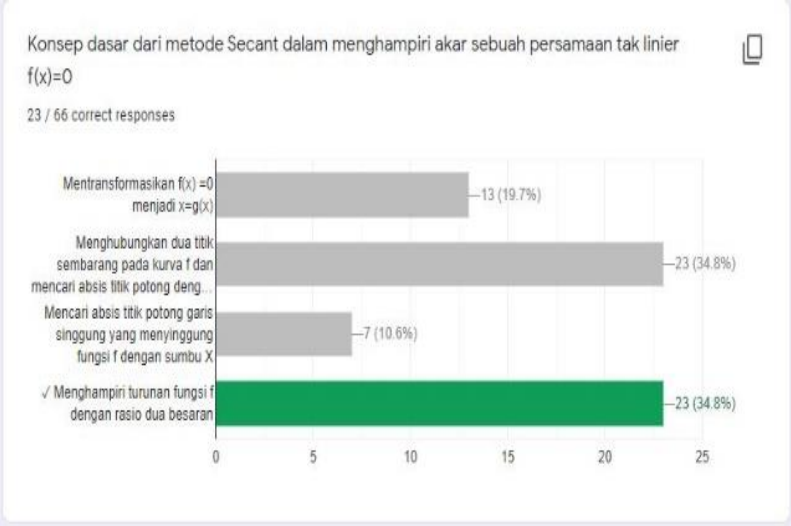

Figure 5: Student's answer to the fourth question

The fundamental question of the concept of the secant method turned out to be a problem for students, as only 34.8% answered correctly. A total of 34.8% chose the second answer that is connecting two arbitrary points on the f curve and looking for the absis of the cut point with the X-axis, students who chose this answer mistakenly assume that the principle of the false-position method with the secant method is basically the same, the fundamental difference, namely the basic principle of the secant method starts from the problem of functions whose derivatives are difficult to calculate, so the first derivative of the function is approached by (Sutarno & Rachmatin, 2017). Students who choose the first answer are confused by the fixed-point iteration method, while the student who chooses the third answer is confused with the Newton-Raphson method principle. From the fallacy of this student choice it can be concluded that the basic principles of the four methods (the false-position method, the Newton-Raphson method, the fixed-point iteration method, and the secant method) still need to be explained again by the teacher. Look at the answer to the following fifth question:

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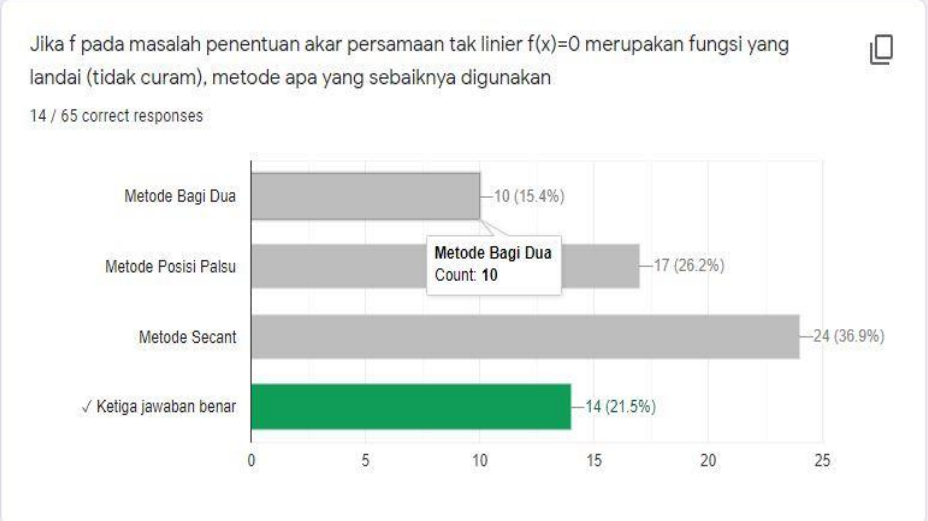

Figure 6: Student's answer to the fifth question

The student actually has chosen the correct answer for the fifth question, but because the first three answers are correct, then the correct answer is the fourth answer. Only 21.5% of students answered correctly. In the answer to this fifth question, students are less thorough in answering, but conceptually they have understood the concept correctly for method two, namely the wrong position method and the secant method so that the third method can be applied to functions that have a slope that is not steep.

DISCUSSION

From the analysis of answers or analysis of difficulties in answering the five questions posed to students who have studied the material of the roots of nonlinear equations, it can be concluded: students still do not understand properly the basic principles of iterative methods that have been studied, this is evident from the questions posed about the advantages and disadvantages of each iterative method, as well as from fundamental questions about the basic principles for each of them. It therefore takes a more intense effort to test the student's understanding after completion of one taught material, and then re-discuss the material that has not been properly understood.

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