The Use of Programming Software Based on Pascal to Optimalize Study Process and Learning Outcomes of Mathematics Education Student in Numerical Method Course

Atma Murni*), Rini Dian Anggraini
Mathematics Education, Riau University
murni_atma@yahoo.co.id

Abstract. The aim of this research is to describe student learning process and learning outcomes in Numerical Method course with the use of prgramming software based on Pascal. The subject of this research was the students of mathematics education study program who studied Numerical Method course in the even semester of academic year 2018/2019 consisted of 69 students. The instruments of this research are observation sheets for thirteen meetings and learning outcomes test for three times of quiz. The topics consisted of: error, iteration, root of nonlinear equation, system of linear equations, interpolation, and integral. The calculation that usually calculated by using calculator, continued by using programming software based on Pascal. Observation result shows that the students were enthusiatic in learning process and able to match the answers that manually calculated by using calculator with to calculation by using programming software based on Pascal. The means of student's learning outcomes in 1st quiz, 2nd quiz, and 3rd quiz are 70,48; 65,55; and 76,59 with the final mean 70,87. The final mean of learning outcomes is categorized as medium.

Keywords: software based on Pascal, numerical method.

1. Introduction

Numerical method course is a 3 credits compulsory course given to mathematic education study program student in semester five. After taking this course, student expected to has these competencies: (1) to comprehend intuitively some of numerical methods to basic problems in mathematic; (2) to know the concept of error, analyse and estimate it; (3) to develop the experience in implementating numerical methods with computer (Atkinson, 1985; Costica, 2016; Fronberg, 1974; Mathews, 1992; Sastry,1983).

The topics consists of: error, iteration, root of nonlinear equation, system of linear equations, interpolation and integral (Atkinson, 1985) . The course given to the comprehension of numerical method procedure. For each topic it is started with the theory that underlies it, continued with giving detailed examples that lead student to calculation needed to find the algorithm. For implementation of computer programming, the algorithme presented using pseudocode translated into Pascal programming language (Mathews, 1992).

Numerical method is the technique that used to formulate mathematical problem so that it can be solved with the operation of addition, substraction, multiplication, and division (Mathews, 1992). With the development of digital computer that is rapid and applicable, therefore the role of numerical method is improving. Numerical method is able to handle the large system of linear equations, nonlinearity, and complex geometry which often impossible to solve analytically (Mathews, 1992; Sastry,1983). Hence, numerical method course becomes a compulsory in curriculum of mathematics education after Basic Science 1991. Nowadays, KKNI-based curriculum presenting numerical method as a compulsory course that is useful for mathematic teacher candidate as the knowledge of the topics of mathematics in school and further education.

Numerical solution is a solution of mathematical problem using numerical method and generate the solution as the approximate solution. The steps to find the numerical solution are: (1) modelling; (2) selecting numerical method and building the algorithm; (3) translating algorithm into programming language; (4) doing the operation, documentation, and program maintenance; (5) interpreting program outcome (Bhuyan et al., 2014; Costica, 2016; Glaser-Opitz, 2016; Handayani et al., 2017; Murni, 2012). Outline of numerical methods categorized into 4: (1) root of nonlinear equation; (2) system of linear equations; (3) interpolation; (4) numerical integration.

The students found the difficulty to solve numerical problem from third step.It was caused the students did not have good competency to translating the algorithm into programming language (Susanti et al., 2011). Therefore, the aim of the course was not yet achieved optimally. To solve this osbtacle, the development research of programming software based on Pascal in 2014 and programming software based on Matlab in 2015 has been done. The software has been using since 2016 by students independently without face to face accompaniment. It was caused by 3 credits course set that was not sufficient yet to use programming formally in the classroom. This action could not optimalize learning process therefore the learning outcomes did not reach the expected competencies.

To overcome the unoptimal learning process therefore it was necessary to do an action with assigned the students formally in the classroom with minimum additional time 50 minutes per week to use programming software based on Pascal as the translation result for each algorithm formulated in learning process (Clark,et al., 2018; Kadir, 1991). The programming could be used by students to check some of the calculations calculated manually using calculator. Programming also could be used to solve complex problems which are unable to solve analytically in various forms.

The use of programming software based on Pascal has been done in the classroom in 50 minutes per week as the additional of 3 credits learning process. The Implementation was facilitated by the lecturer of the course and two final year students.

2. Methodology

This research was conducted in mathematics education study program in even semester academic year 2018/2019. The subject is the student who took numerical method course consisted of 2 classes with 69 students. The daata of this research is qualitative and quantitative data (Bogdan et al., 1982; Borg et al., 1983). The qualitative data is the activity of the students and lecturer using programming software based on Pascal in solving complex mathematical problem. The quantitative data are score of student learning outcome for each quiz. Data collecting was conducted by doing observation, interview, and test. The observasion was conducted when the students used the programming software based on Pascal, meanwhile the interview was conducted after class. The test was given three times with the topics: (1) nonlinear equation; (2) system of linear equations; (3) interpolation and numerical integration. The qualitative data from observation and interview were analysed using descriptive analysis technique with the following steps; (1) presenting data recapitulation of observation and interview in form of narrative for each meeting; (2) interpreting data of recapitulation of observation and interview. Quantitative data was obtained from 3 quiz result using criteria-referenced assesment. The final outcome was obtained from the mean of 3 quizes.

The research was conducted in three steps: (1) preparation; (2) implementation; (3) data analysis and writing the research report. In preparation, the activities that have been done were: (1) preparing learning materials; (2) preparing instrument: observation sheet, interview guidelines and test. In implementation step, the activities that have been done were: (1) implementing programming software based on Pascal in various relevant numerical method; and (2) observing students activity. In

analysis step, the activities were: (1) analysing and making conclusion from the obtained data therefore the research findings were obtained; and (2) making research report.

3. Result and Discussion

Numerical method course takes face-to-face learning process to give the all topics in 13 meetings and giving the quiz in 3 meetings. First meeting of the course was started by reminding the student about building the algorithm from several mathematical problems such as Taylor series. The students have received the concept of building the algorithm in Computer and Programming course. In numerical method, students are required to apply the konwledge and skill of building the algorithm and making program that they already have. The skill of building the algorithm is very important in numerical method course.

The solution of the first topic about root of nonlinear equation was obtained using bisection method, regula falsi method, secant method, newton-raphson method, and modification of newton-raphson for polynomial. The topic about root of nonlinear equation needed 3 face-to-face meetings. The first face-to-face meeting discussed bisection methods and regula falsi method. The second face-to-fce meeting discussed secant and N-R method, and the third face-to-face meeting discussed modification of N-R for polynomial. The procedures that shoud be followed by student for each meeting were: (1) examining the procedure for each solving method; (2) finding out the algorithm; (3) calculating by using calculator; (4) checking the result by using programming based on Pascal. For the 4th procedure, it was conducted by adding 50 minutes additional times as ditermined in this research that shown at Figure 1

Figure 1. Lectures Apply the Pascal-based Programming

Before having face-to-face meeting, the students had reminded to ensure every laptop had Pascal programming application isntalled and copied all programming based on Pascal for every methods. Additional time for every week was used by the student to check the suitability manual calculation that had been done with the calculation by using program based on Pascal. Various activities appeared: (1) the students could immediately run the program based on Pascal which had been copied; (2) the display of the program was incomplete; (3) the display did not match with the manual calculation; (4) the program could not be run. With the description of these activities, the students were assigned to finish using program based on Pascal individually. Next, students were assigned to find the solution of several nonlinear equations in the numerical method textbook (Murni, 2012). The second face-to-face meeting discussed secant and N-R method, dan the third face-to-face meeting discussed about

modification N-R for polynomial. The students could do the activities smoothly, but the time were still not sufficient and should finished the calculation using program based on Pascal individually.

The next topic was about system of linear equations, which consisted of: (1) upper triangular and lower triangular linear system; (2) gauss elimination method; (3) triangular decomposition (Doolittle, Crout, and Cholesky); and (4) Jacobi and Gauss-Seidel iteration. The topics were given into 5 meetings, and likewise the using of program based on Pascal. The process of finding out the algorithm that had long step was gauss elimination. For each topic, by usimg program based on Pascal, students were able to calculate for several questions. Students should associate the use of program based on Pascal with procedure of each method. The purpose was to make the students understand procedures for every numerical method.

The third topic was interpolation which consisted of: (1) Newton's divided difference interpolation; (2) Newton Forward and Backward interpolation; (3) Lagrange interpolation. Through 3 meetings, stoudents were able to calculate using program based on Pascal. Students inputted the data to interpolate the certain data point that was on several other data points. With program based on Pascal, students were able to calculate data points to interpolate various data point. The last topic was about numerical integration that consisted of: (1) trapezoidal rule; (2) Simpson rule. This topic is useful to estimate approximation area under curve. Students could use program based on Pascal to calculate minimum area of five curves in numerical method textbook.

One example as the result of program based on Pascal to find root of nonlinear equation using bisection method presented below (Figure 2). The nonlinear equation given was $f(x) = x^2 + \ln x = 0$. First, students worked manually to find the solution of nonlinear equation given up tu 14 iterations using calculator and took time 45 minutes. Figure 3 shown citation of calculation using calculator. With program based on Pascal, it took 2 minutes for finding the solution. Therefore, if students understand with the procedural of the solving method then the students could be able to calculate using Pascal based program. The same condition applicable to the other numerical methods.

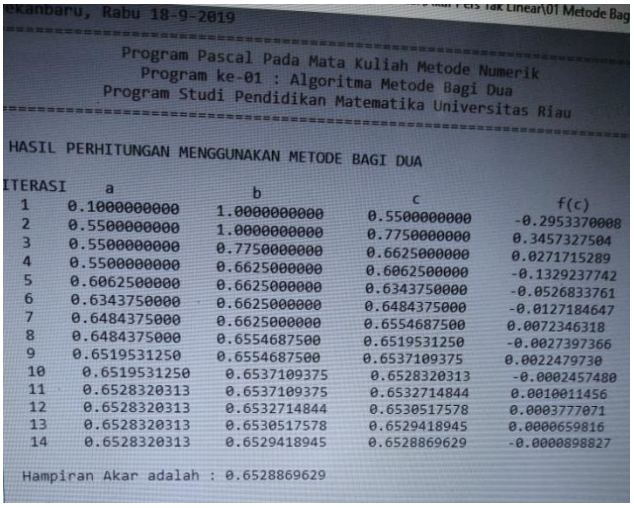


Figure 2. Calculation result of Bisection Method

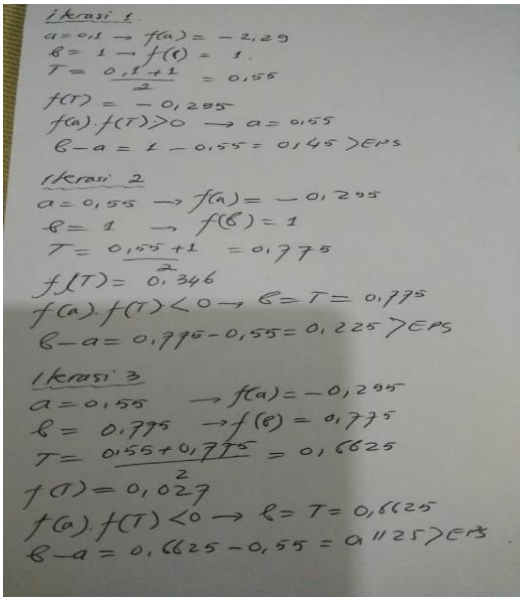
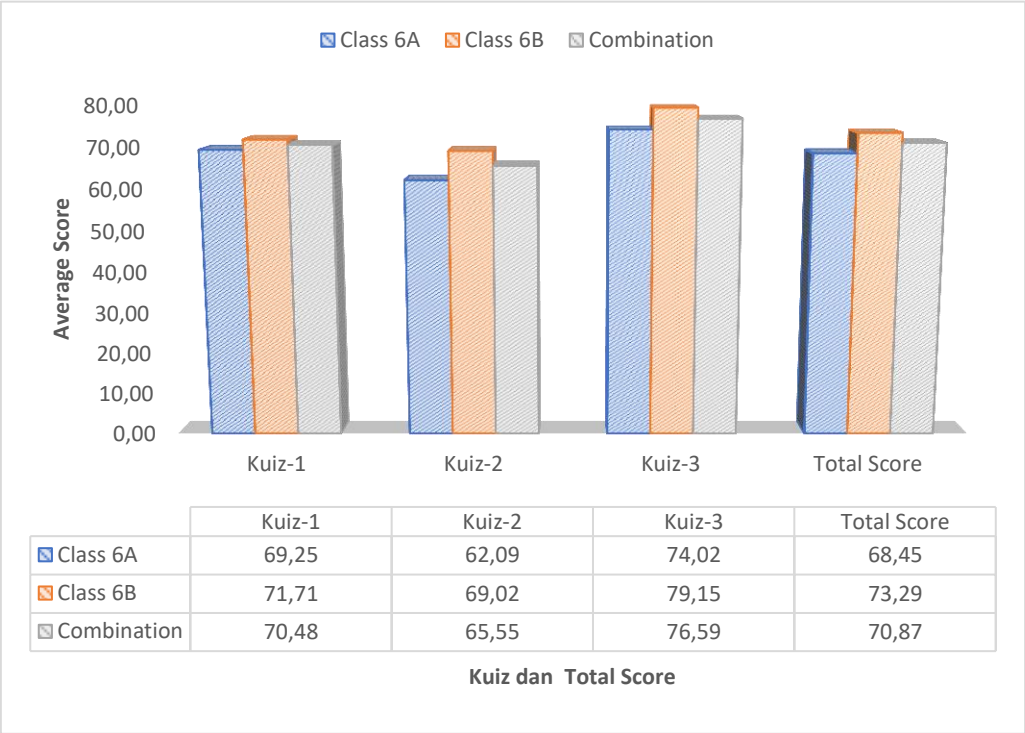


Figure 3. Citation of Calculation Using Calculator

Student outcomes with learning improvement in the form of giving 50 minutes additional time for every week to use Pascal based program can be seen in Figure 4. Student outcomes in 1st and 3rd quiz categorized as good and the 2nd quiz categorized as medium. It was caused the students were not skilled yet to use calculator and did not use the Pascal based program intensively. Through the interview with the students, it was known that students seldom do self-practice calculating with calculator individually.



	Kuiz-1	Kuiz-2	Kuiz-3	Total Score
Class 6A	69,25	62,09	74,02	68,45
Class 6B	71,71	69,02	79,15	73,29
Combination	70,48	65,55	76,59	70,87

Figure 4. Numerical Method Learning Outcomes

4. Conclusion

The conclusions that can be stated from the research result are:

1. Accompaniment of the using onf programming software based on Pascal give simplicity to the students to find out the solution of various numerical methods in short time.
2. Accompaniment gives the optimal result if the students examine the procedure of numerical methods and intensively practice calculating with calculator or Pascal based program

So that the learning objectives can be achieved optimally, there are several recommendations:

1. Students must understand the procedure of numerical method
2. Students must do self-practice routinely using calculator and computer program

Acknowledgement

Thank you to FKIP chairperson for providing the funds of DIPA PNBP BLU FKIP UNRI 2019 for facilitating this research.

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