The Influence of Mathematical Logic Ability Toward Computer Programming to Solve Mathematical Problems

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Abstract. A computer program is a series of commands to solve complex mathematical problems through mathematical modeling. Computer programs are made with certain programming language based on syntax, semantics, and logic. Thus, knowledge of logic is certainly related to computer field. This study aims to find out the influence of mathematical logic students' abilities of making computer programs to solve mathematical problems, especially in numerical method course.The sample of this study arethe students ofmathematics education departement of Muhammadiyah University of Purworejo, who took numerical methods course. There are 30 students as sample of this study taken randomly. The instrumentsof data collectionare practical tasks of making programs to solve a system of non linear equation and interview about the process of making computer programs. The research data are processed by linear regression analysis. The significance level used in this study is 5%. Based on the research data, the linear regression equation is obtained $y = 30{,}48262 + 0{,}612498\,x$, t_{count} = 3.332 and t_{table} = $t_{0.975}$ = 2.048. Thus, $t_{count} > t_{table}$. Therefore, the null hypothesis is rejected. It means that the mathematical logic students' ability has influence on the ability of making computer programs.

Keywords: logic, mathematics, programs, computers

1 Introduction

Along with increasing the development of technology rapidly, the use and empowerment of computers have entered in various aspects of life. In reality, the empowerment of computers has now been applied in various fields of work such as offices, banking, medicine, weapons, education, or other business worlds. In future, to help solving human works quickly and precisely, empowering computers certainly will be more widespread with increasingly sophisticated technology.

Today, empowerment of computers in education world is also growing faster. Especially in mathematics learning, the role of computers in fact has very broad implications in improving the quality of learning. In this case, several research results show that computer-assisted mathematics learning can improve the quality of mathematics learning that has implications onincreasing students' creativity, improving mathematical skills, conceptual understanding, reasoning, communication, connections, and mathematical problem solving. On the other hand, Arum states that logical-mathematical intelligence has an important role in learning mathematics [1].

Mathematical problems in everyday life are indeed very complex and varied. In this regard, learning mathematics is expected to take contextual mathematical examples. In mathematics, this strategy is often called realistic mathematics. In addition, to improve

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accuracy and speed in problem solving, learning mathematics in higher education has used computer aids. Related to the accuracy in solving mathematical problems, Darminto states that students' errors in choosing the right approach or applying algorithm and performing arithmetic operations to solve the problems of this study occur approximately 60% [2]. Furthermore, Darminto also explains that the empowerment of computer technology in higher education can improve the quality and quantity of outcomes and outputs from the learning process [3]. Then, Fumiyuki explains that learning of computer-assisted mathematics in Japan was proven to be able to increase the effectiveness of learning because computers could help to visualize geometric shapes, perform number operations quickly and accurately in solving some mathematical problems [4]. In the field of Calculus, Robert & Speer explain that learning calculus will be successful and more effective if it is carried out meaningfully and the process is carried out theoretically and practically using computer aids [5].

Computer programming aims to help in solving human problems quickly and accurately using computers. Programming languageisa medium for interacting between humans and computers [6]. The use of computers in learning mathematics in higher education theoreticallycan not be separated from the ability of students in various matters relating to the process of making computer programs. Saxton states that a computer program is a series of instructions (also called code) given to the computer to perform some tasks [7]. The abilities needed by someone who will make a computer program include: logic skills, knowledge of algorithms and flowcharts, as well as accuracy in writing the syntax of programming languages. If any of these abilities are lacking, it is certainly possible that this will affect the process of making computer programs so that it doesn't work well. Therefore, a programmer is expected to have these abilities in order to be able to make computer programs properly.

The ability of logic is built through various scientific aspects, including: lectures, research, and problem solving both theoretically and practically. The word *logic* comes from the ancient Greek word *logos* which means the result of mind consideration which is expressed in words and stated in language. In the departement of mathematics education, the main subject of mathematical logic is included in the subject of basic mathematics introduction. The relationship between mathematics and computers is that mathematics can find rational logic equations which can be translated into computers through programming language. One of the most important applications of mathematical logic in the use of computers is the ability in programming [8].

Computers can do mathematical rational logic calculations quickly and precisely. The limitations of computers can be overcome by mathematical logic, while mathematical problems can be computerized like counting the amount of sand in a certain scale. Mathematical logic has a very important role in several matters, including: (1) increasing thinking rationally, critically, straightly, steadily, orderly, methodically, and coherently; (2) increasing the ability to think abstractly, carefully, and objectively; (3) increasing the ability to think systematically, sharply, and independently; (4) increasing the accuracy and correctness to avoid mistaken thinking; (5) increasing the ability in analyzing an event.

Both mathematics and computers have a close relationship. This statement is supported by the results of Logsdon's research which says that people with logical-mathematical learning styles learn best when they are taught using visual materials, computers, statistical and analytical programs, and hands-on projects [9]. They prefer structured, goal-oriented activities that are based on math reasoning and logic rather than less structured, creative activities with inactive learning goals. Then, in the important aspect of computer programming in helping to solve mathematical problems, Kalelioğlu & Gülbahar state that computer programming is perceived as an important competence for the development of problem solving skills in

addition to logical reasoning [10]. In Bandung, the result of Bernard's research on the use of computers in mathematics learning is concluded that the mathematical reasoning ability of high school students increased through the Adobe Flash CS4 game [11].

This study aims to improve the ability to solve mathematical problems using computers. Therefore, this research involves student activities [15]. In order to use a computer properly, the mathematical logic ability must also be good too. Research on the relationship between mathematics and computers was also conducted by Vladimir Estivill in 2010. He states that the development of mathematical problem solving skills can be done by using several concepts of computer science [16]. Furthermore, Prodromou, have also conducted this kind of research to develop teacher professionalism by using computers [17]. Based on the above background, the researcher suspects that the logic ability possessed by students influences the ability to make computer programs to solve mathematical problems in numerical methods courses.

2 Methods

This research is conducted at Muhammadiyah University of Purworejo in the Mathematics Education Departement from March to July 2019 using students taking Numerical Method course as samples.There were 30 students as samples taken randomly. The instrument to take data used mathematical logic tests and assignments to make computer programs to solve the problem of non-linear equations. The significance level of this study is 5%. Data is processed and analyzed by linear regression using computer aids.

3 Results and Discussion

After the researcher determines the research sample, the next step of this research is to create a research instrument that is a set of mathematical logic questions and questions about the system of non-linear equations which will be solved through a computer program. The students taken as sample are the participants in numerical methods courses. In accordance with the curriculum applicable to the mathematics education departement, some important subjects in the numerical method courses used in this study are to determine the roots of non-linear equations, systems of linear equations, and integrals.

The implementation of this research starts from the presentation of the problem system of linear equations and problems to determine the roots of non-linear equations to students. Before making a computer program, students are given knowledge about given several methods to determine the roots of non-linear equations namely Bisection Method, False Position Method, Newton-Raphson Method, and Secant Method. Then, they are given problems to find the roots of non-linear equations. Before making a computer program, they are asked to make algorithms and flowcharts based on the method chosen. Although students can manually find the roots of the equation in question, most students have not been able to make algorithms and flowcharts correctly. This is consistent with the results of research conducted by Moala which states that although some students can easily find the correct solutions to the problem (s) at hand, the algorithms that these students create are not always the ones that would, when implemented, produce the correct solution (s) [12]. Data from this research are as follows:

Table 1. Score of Mathematical Logic Ability Tests and Computer Programming

Sample	X	Y	Sample	X	Y	Sample	X	Y
1	86	84	11	40	45	21	60	65
2	70	68	12	59	78	22	65	40
3	82	80	13	70	89	23	68	87
4	90	92	14	65	50	24	50	75
5	75	80	15	66	60	25	74	78
6	86	85	16	68	75	26	46	80
7	67	70	17	58	50	27	54	45
8	78	80	18	44	50	28	78	90
9	80	85	19	38	85	29	60	50
10	74	82	20	70	60	30	57	58

To calculate the data of research results using simple regression analysis, researcher created a computer program with the Matlab language. In computer science, Matlab has many advantages, including: mathematical computation/ numerical computation, programming languages based on matrices, memory management is set automatically, visualization of data analysis, and equipped with toolboxes for special applications. In this regression analysis program, the data of the research is entered into the program. Below is presented in full the linear regression analysis program with Matlab.

```
% LINEAR REGRESSION PROGRAM FOR PROCESSING RESEARCH DATA
%By BAMBANG PRIYO DARMINTO
clear;clc;
disp(' LINEAR REGRESSION PROGRAM ');
disp('-----------------------------------------------');
x=[86 70 82 90 75 86 67 78 80 74 40 59 70 65 66 68 58 44 38 70 60 65 68 50 74 46 54 78 60 57];
y=[84 68 80 92 80 85 70 80 85 82 45 78 89 50 60 75 50 50 85 70 65 40 87 75 78 80 45 90 50 58];
n=max(size(x));% determine the number of data records x
zx=0;% declare the zx variable
zy=0;% declare the zy variable
zxx=0;% declare the zxx variable
zxy=0;% declare the zxy variable
for i=1:n % look for the amount
   zx=zx+x(i);%count the number of x
   zy=zy+y(i);% count the number of y
   zxy=zxy+x(i)*y(i);% count the number of x.y
   zxx=zxx+x(i)*x(i);%calculate the number of x squares
end
b=(n*zxy-(zx*zy))/(n*zxx-zx^2);%count the value of b
xbar=zx/n; %count the number of x
ybar=zy/n; %count the number of y
a=ybar-b*xbar; %count the number of a
%display all calculation results
disp([' Amount of data x = ',num2str(zx)]);
disp([' Amount of data y = ',num2str(zy)]);
disp([' Amount of data x.y = ',num2str(zxy)]);
disp([' Amount of data x^2 = ',num2str(zxx)]);
disp([' Average value x = ',num2str(xbar)]);
disp([' Average value y = ',num2str(ybar)]);
disp(['Value b = ',num2str(b)]);
disp(['Value a = ',num2str(a)]);
```

Output program:

```
LINEAR REGRESSION PROGRAM
------------------------------------------------
Amount of data x  = 1978
Amount of data  y = 2126
Amount of data x.y= 143478
Amount of data x^2 = 135810
Average value x = 65.9333
Average value y = 70.8667
Value b = 0.6125
Value a = 30.4826
```

Based on the output above, a regression equation of $y = 30.4826 + 0.6125x$ is obtained.
x: mathematical logic ability
y: the ability to make programs
Based on computer calculations, values of a = 30.4826 and b = 0.6125 so that the linear regression equation can be formulated as y = 30.4826 + 0.6125x. The slope or direction coefficient of the equation is b = 0.6125, while the intersection point of the linear regression curve is at (0; 30.4826). Then, s_b is calculated (standard deviation for value b). Then the value of s_b is used to calculate the value of t.

Furthermore, to test the significance of the effect of the ability of mathematical logic on the ability to make a program, it is necessary to test a hypothesis with the following steps:

1. H_0: $b = \theta = 0$; there is no influence between the ability of mathematical logic to ability make computer programs.
   H_1: $b \neq 0$; there is an influence between the ability of mathematical logic to the ability to make computer programs.
2. $\alpha = 5\%$ and $dk = n-2 = 30-2 = 28$.
3. Calculate the value of t with the formula $t_{calculate} = \frac{(b-\theta)}{sb}$, then this value is consulted to the table with $t_{0,975}$ and dk = 28. If $t_{calculate} \geq t_{(0.975;\ 28)}$ or $t \leq -t_{(0.975;\ 28)}$, then H_0 is rejected.

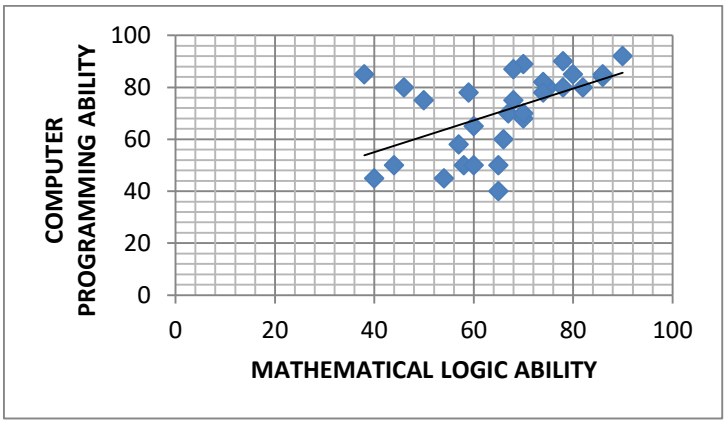

Fig. 1. Scatter Diagram of Mathematical Logic and Computer Programming Ability

Based on the calculation results obtained s_b = 0.1838, and $t_{calculate}$ = 3.3318. With dk = 28, we get $t_{table} = t_{(0.975;\ 28)}$ = 2.048. Thus, $t_{calculate} \geq t_{(0,975;28)}$. So H_0 is rejected and this shows that the value of b = 0.6125 is significant. Therefore, the conclusion of this research is that there is an influence between the ability of mathematical logic and the ability to make computer programs for students. It means that if the mathematical logic ability of students is good, then students can make computer programs well and vice versa. The results of this study are in line with Sauter's study which states that recently; however, individuals have begun to claim that programming skills are associated with language aptitude [13]. This, in turn, has caused some to reflect on the relative merits of the two philosophies. In that spirit, this study was undertaken to assess the relative roles of mathematical aptitude and language aptitude in the development and enhancement of programming skill. It was found that both types of aptitudes are associated with programming skill: mathematical aptitude is associated with an ability to learn rules of logic and language aptitude is associated with an ability to team syntatic rules. Implications for the teaching of programming are discussed. The implications of the results of this study are also almost the same as the results of research conducted by Özgen Korkmaz in 2016. He states that there is a positive influence between achievement in computer programming activities based on Scratch and Lego Mindstorms Ev3 on problem solving abilities and students' logical-mathematical thinking abilities [14]. The results of a similar study carried out for 16 months in the Czech Republic with a heuristic approach to 62 students aged 12-18 years can improve the ability to solve mathematical problems [18]. Also, in connection with the results of this study, Nolan and Herbert state that the use of computers can improve the problem solving ability of linear functions [19]. However, research on the use of computers in the mathematics learning of elementary school students in Catalan, Spain, England has no positive effect on increasing mathematics scores [20]. In another study, Khodadady & Dastgahian state that mathematical logical intelligence has a positive and significant correlation to English language ability [21].

4 Conclusions

Based on the discussion of the research data, it is concluded that there is a significant influence thatthe ability of students' mathematical logic affectedto the ability in making computer programs to solve mathematical problems. Therefore, if the students' mathematical logic ability is good, they can make computer programs well.

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