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The Relationship Between Mathematical Ability and Programming Ability of Computer Science Education Students

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Abstract— Mathematics is one of the sciences that can improve thinking skills and contribute to solving daily problems as well as the world of work. Some compulsory subjects in the Computer Science Education study program are in the field of mathematics. Also, one of the important things for students of Computer Science Education is programming ability. This fact underlined the purpose of this research. This study aims to examine whether there is a relationship between mathematical ability and programming ability of students of Computer Science Education. It employed a survey method with a correlational approach. The subject was 132 students of Computer Science Education. The technique sampling was a purposive random sampling. The quantitative data used to see the relationships were students' basic mathematics (BM) and basic programming (BP) data. The data was processed with IBM SPSS Statistics 25. Several previous studies revealed a relationship between these abilities descriptively. The difference with this research was quantitative testing the relationship between mathematical ability and programming ability. The finding of this study was that the average BM and BP scores of students have very small differences, which were 63.72 and 63.94. It can be concluded that there was a strong relationship between mathematical ability and programming ability of students of Computer Science Education.

Keywords— mathematical ability; programming ability

I. INTRODUCTION

Curriculum serves as a guideline for the implementation of education as well as an illustration of what educational practices should be carried out and expected outcomes [1]. Based on the curriculum structure that applies in the Computer Science Education Study Program, there are seven courses in mathematics. These seven subjects are included in the compulsory field of expertise. This integration of mathematics courses indicates that the application of mathematics plays an important role in mastering computer science [2][3][4]. The Organization for Economic Co-operation and Development (OECD) states that mathematics is an important tool for young people because they face problems and challenges in their personal, work, social, and scientific aspects in their lives [5]. In other words, mathematics teaches students computational thinking and focuses on the application of solving real-world problems [6].

The development of 21st-century information and communication technology is also based on the development of mathematics, including the branches of number theory, algebra, statistics and probability, and discrete mathematics [7]. The foundation of the branch of mathematics begins with the deepening of basic mathematical material. Therefore, basic mathematics courses are the foundation to support the development of students' mathematical ability.

Achieving thinking skills or dynamic mathematical ability such as reasoning, communication, connection, modeling, and mathematical problem solving requires a vehicle for communication in verbal and written forms [8] [9]. The vehicle for communication can be in the form of a single or multiple representations arranged in a mathematical language that expresses one's ideas to others or himself verbally or in writing, through symbols, graphs, tables, images, equations, concrete objects, or other forms. However, in the implementation of mathematics learning in higher education, the achievement of student representation ability is experiencing obstacles. Students do not understand the common thread among concepts, ideas, and material to be represented [8]. Mathematical representations are part of the mathematical ability.

The relationship with programming ability is that the mathematical representation is as a bridge that represents the ideas or languages used in making computer programs. A computer program is a software that contains a series of sequential instructions written to perform a series of tasks for a computer. Computer programs are made to facilitate human work. A language is needed in creating the program used to instruct the computer. This language is known as a programming language. A programming language is a set of syntax and semantic rules used to define computer programs. This language allows a programmer to determine exactly the data to be processed by a computer, how this data will be stored/forwarded, and what types of steps will be taken in various situations [10].

Programming ability is supported by an understanding of the programming language used. According to the level of proximity to computer machines, programming languages consist of several parts. First, a machine language: that is,

languages that give commands to computers using binary language codes. Second, low level language that gives orders to computers using short codes. Thirds, a middle-level language which is a computer language that uses a mixture of instructions in human language words and symbolic codes. The last is high-level language as a series of instructions that use elements of human words so that they are easier to understand [10]. The programming languages used are for example ALGOL 68, Pascal, C, C ++, JavaScript, Java, etc. [10][11][12][13]. Characteristics of programming languages include: (1) the use of symbols, (2) the use of variables, constants, and operators, (3) the conditions, repetitions, and mathematical functions, and (4) the structured algorithms/steps. These characteristics are in line with mathematical characteristics. Also, the application of mathematical logic is closely related to making computer program algorithms [2] [3][4]. Then, based on the description above, the purpose of this study is to examine the relationship between mathematical ability and programming ability of students of Computer Science Education.

II. METHOD

A. Research Subject

Subjects of this study were 132 students of the Computer Science Education study program. The subjects of the study share common characters namely have completed basic math courses and basic programming. The subjects of this study were taken because the research subject had entered the formal operational stage. Where at this stage, an individual becomes more scientific and logical in the way they approach problems, can develop the ability to think more abstractly, can imagine hypothetical situations, and can determine possible outcomes without the need to observe [14]. The technique sampling used was a purposive random sampling.

B. Data Collection

The data in this study was collected using an achievement value data on basic mathematics courses and basic programming — achievement of basic mathematics courses to represent students' mathematical ability. The achievement of basic programming courses represents the programming ability of students. These two courses were chosen because they are fundamental subjects to support mathematical ability and programming ability.

C. Data Analysis Technique

The data was then analyzed by using quantitative data analysis. Quantitative data analysis is used to analyze the relationship between mathematical ability and programming ability of students of Computer Science Education. The form of quantitative data in this study included achievement value data in basic mathematics courses and basic programming. The data was processed with IBM SPSS Statistics with $\alpha = 5\%$. Quantitative analysis of the relationship between mathematical ability and programming ability was done in the following stages:

- Creating a table of data of achievement of basic mathematics and basic programming

- Performing normality tests to determine the normality of data on basic mathematics achievement values and basic programming using the Kolmogorov-Smirnov statistical test. The data is normally distributed if the significance value is > 0.05 (sig. 0.05). The hypothesis formulation on the normality test is H_0: Data is not normally distributed and H_1: Data is normally distributed.

- Conduct the Pearson Correlation test to determine the relationship between mathematical ability and the programming ability of students of Computer Science Education. If the value is a sig. < 0.05, there is a significant relationship (H_1 is accepted). The formulation of the hypothesis in the correlation test is: H_0= There is no relationship between mathematical ability and the programming ability of students of Computer Science Education. H_1= There is a relationship between mathematical ability and the ability of programming students Computer Science Education.

III. RESULTS AND DISCUSSION

The results of this study are quantitative data obtained from the values achievement of basic mathematics courses (BM) and basic programming (BP). The data was processed from 132 students of the Computer Science Education program. The initial step of data analysis in this study was to analyze the achievement value data of basic mathematics courses and basic programming with descriptive statistics.

TABLE I.   DATA OF BM AND BP ACHIEVEMENT

	N	Min	Max	Mean	Std. Dev
BM	137	0	91.70	63.72	18.49
BP	137	0	94.00	63.94	14.99

Based on Table I, the average value of Basic Mathematics and Basic Programming has a relatively small difference, namely 63.72 and 63.94. The minimum value of the two courses is the same, which is 0. The maximum value for the two courses is relatively small. The maximum value of Basic Mathematics 91.70 and the maximum value of Basic Programming is 94. Therefore, it can be temporarily drawn that students' mathematical abilities are related to their programming ability.

This interim estimate is strengthened through inferential statistical analysis with IBM SPSS Statistics 25 with $\alpha = 0.05$. Inferential statistical analysis begins with normality testing. The next testing steps are determined based on the normal distribution of the data obtained.

TABLE II. NORMALITY TEST RESULTS OF BM AND BP DATA

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
BM	0.106	137	0.001	0.936	137	0
BP	0.168	137	0	0.857	137	0

a. Lilliefors Significance Correction

Criteria for testing hypotheses based on significance or sig., Ie if sig ≥ α, then Ho is accepted. Seen in Table II shows sig. BM and BP data respectively < 0.05 (Kolmogorov-Smirnov), then Ho is rejected. It means the data values of basic mathematics achievement and basic programming are not normally distributed.

Normal data on basic mathematics achievement values and basic programming of Computer Science Education students can be seen based on the results of the Q-Q Plot in Figures 1 and 2.
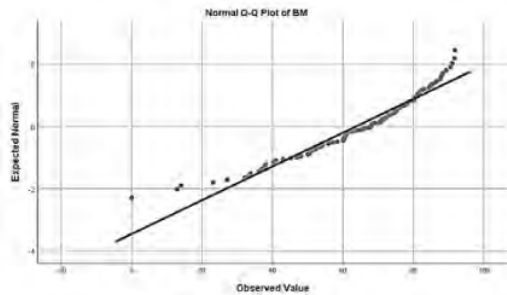

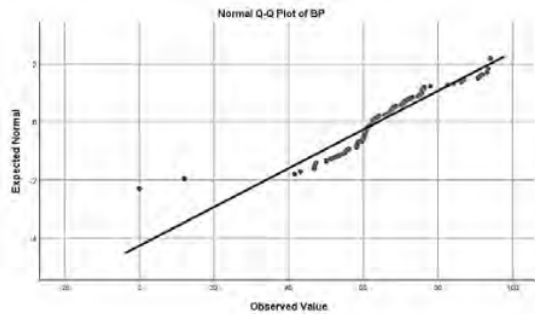Fig. 1. Normality Test with QQ Plots for Basic Mathematics Data

Fig. 2. Normality Test with QQ Plots for Basic Programming Data

Based on Figures 1 and 2, it can be seen that the distribution of BM and BP data has several data that are far from straight lines, meaning that the data in both classes are not normally distributed.

The next step is to do the Pearson Correlation test to find out the relationship between mathematical abilities and the programming ability of students of Computer Science Education. The Pearson Correlation data test results can be seen in Table III.

TABLE III. PEARSON CORRELATION TEST RESULTS OF BM AND BP DATA

		BM	BP
BM	Pearson Correlation	1	0.634
	Sig. (2-tailed)		0
	N	137	137
BP	Pearson Correlation	0.634	1
	Sig. (2-tailed)	0	
	N	137	137

b. Correlation is significant at the 0.01 level (2-tailed).

c.

Table III shows that the Pearson Correlation (r) coefficient is 0.634. It indicates that there is a strong relationship between mathematical abilities and programming ability of students of Computer Science Education. Furthermore, the direction of the relationship is positive because the value of r is positive. So that, the higher the mathematical abilities of students, the higher their programming ability. Based on Table 3, it is known that the significance value is 0 (< 0.05). This shows that the strength of the relationship between mathematical abilities and the programming ability of students in Computer Science Education is very significant.

The results of the analysis of descriptive and inferential statistical tests show that there is a relationship between mathematical ability and the programming ability of students of Computer Science Education. It is confirmed by previous studies [2][3][4]. This is because mathematics is an important tool for young people to face problems and challenges in their personal, work, social, and scientific aspects in their lives [5]. Especially teaching students computational thinking and focusing on the application of solving real-world problems [6]. Ref [15] further stated that mathematical contributions were very large in building and developing information technology and computers because mathematics is logic. In fact, the information technology and computers were made as a basis for programming; information technology and computer programming languages use binary numbers "1" and "0", and their operations use mathematical algebraic operations; basic hardware and software development, basic development and determination of bits in a computer, basic network implementation and development [15].

IV. CONCLUSION

It can be concluded that there is a relationship between mathematical abilities and programming ability in Computer Science Education students.

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