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Analysis of computational thinking skill predictors on information technology education students

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Abstract. Computational thinking is a skill that must be possessed by everyone, especially students. Factors that affect computational thinking skills must be properly identified to support the development of computational thinking. This study aims to analyze the effective factors, namely gender, mathematical ability, ICT literature, and language skills as predictors of computational thinking. The research subjects were 34 Unesa information technology education students. Analysis of predictor factors using linear regression and concluded that that the level of computational thinking sequentially is effected by mathematical ability, language skills, gender, and ICT literacy.

1. Introduction

"Ubiquitous computing was yesterday's dream that became today's reality. Computational thinking is tomorrow's reality." – (Wing, 2014)

The development of computer science improves social and economic life. At present, everyone is expected to master technology development which is approved by the rapid development of technology [1]. In line with this, students must prepare to have competence in order to be able to use future technology that may not be available at this time. Computational thinking is not a new concept. This concept has been around since the 1960s, an important skill that has been supported in the context of computer science. At first, think about computational considerations about the skills that must be issued by computer experts, but after Wing sparked his vision of computational thinking, these skills became the basic competencies that everyone must master.

In 2006, Wing first identified computational thinking as a thought process in understanding problems with appropriate presentation styles, realizing this issue through abstraction and the development of equitable automatic solutions. Furthermore, in 2014 Wing developed the definition and stated computational thinking as a thinking process which included the problem of formulation as a computer that could effectively provide a solution. Another definition of computational thinking has been given by experts. In essence, computational thinking involves abstraction, algorithmic thinking, problem solving, decomposition, generalization, and debugging [2].

Wing's idea of computational thinking as a skill that must be mastered by everyone is agreed by many parties as evidenced by the many studies and discussions about computational thinking in journals, proceedings, and literature. At the same time, international standards for computational thinking in the

field of education have been developed by various institutions such as the International Society for Technology in Education (ISTE), the Computer Science Teachers Association (CSTA), The National Research Council (NRC), Google, and Microsoft . This shows that computational thinking skills in education and the determination of effective factors in developing computational thinking are important [3].

Determination of factors that effect the development of computational thinking based on existing literature studies. The formulation of the problem in this study are: (1) Is the student gender positively influencing the level of computational thinking skills? (2) Are students' mathematical abilities positively influencing the level of computational thinking skills? (3) Is student ICT literacy positively influencing the level of computational thinking skills? (4) Do the student's language skills effect the level of computational thinking skills? (5) Do gender, mathematical ability, ICT literacy, and language skills jointly effect the level of computational thinking skills?

The purpose of this study is to analyze the factors that effect the level of computational thinking skills so that the formulation of the problem can be answered. Furthermore, these factors are analyzed using linear regression to test how much these factors can predict computational thinking skills.

2. Related Works

Several studies have revealed that gender effects computational thinking skills [4] - [6]. A study presented a significant relationship between the level of self-efficacy in programming, the level of computational thinking skills, and the development of these skills [5]. Other research explores the relationship between gender, self-efficacy, or changes in programming competencies in the process of writing code, teaching programming or robotics. This proves that gender must be included as a variable in acquiring and developing computational thinking skills [6]. Gender factors are also used in concepts related to computer science in general. Therefore, it is assumed that gender has a positive effect on the level of computational thinking skills so it is formulated as follows.

> ***H1****: Student gender has a positive effect on the level of computational thinking skills*

Computational thinking is a concept related to mathematics and computer science as introduced conceptually by Wing (2006). In other words, even though the concept of computational thinking has used basic concepts for information processing and computer science, it also has an important role in developing skills commonly used in mathematics such as problem solving, abstraction, algorithmic thinking, creative thinking, logical thinking, and analytical thinking. Various studies have shown that computational thinking can be done in mathematics. Mathematics has similarities to basic concepts with computational thinking, namely defining problems, analyzing problems, and solving problems [6]. Thus, it can be assumed that mathematical abilities have a positive effect on the level of computational thinking skills.

> ***H2****: Student's mathematical ability has a positive effect on the level of computational thinking skills*

The concepts and applications of computational thinking are based on the basic concepts of computer science. These skills involve knowledge structures based on applications relating to computer science such as problem solving, problem presentation, abstraction, analysis, verification, and reflection through information technology. Computational thinking is a general analytical approach for understanding problem solving and designing computer systems. Computer science is also known as an important thematic area in teaching computational thinking skills. The interaction between students and computers is considered as a form of reflection of computational thinking skills [7], [8]. Thus,

one's knowledge in the use of ICT (ICT literacy) has an effect on the level of computational thinking skills.

***H3**: Student ICT literacy has a positive effect on the level of computational thinking skills*

Mark Steedman, ACL Presidential Address, in 2007 made a statement as follows [6].

"Human knowledge is expressed in language. So computational linguistics is very important ".

Based on the opinions above, it can be concluded that language is a reflection of one's mind. Language is the most natural and most important means of communication. The opinion above is in line with Vygotsky's idea that thinking and language are interrelated processes. The use of language reflects the sharpness of thinking, the appearance of ideas or imagination, the use of memory memories, and action plans [7]. Therefore, language skills are considered as a factor that has a positive effect on the level of computational thinking skills.

***H4**: Student language skills have a positive effect on the level of computational thinking skills*

From the overall relevant research described above, it can be assumed that gender, mathematical ability, ICT literacy, and student language skills positively effect the level of computational thinking skills.

***H5:** Gender, mathematical ability, ICT literacy, and student language skills together have a positive effect on the level of computational thinking skills*

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3. Methods

This study included ex-post facto research. The variables to be examined are: (1) the dependent variable: the level of computational thinking skills; (2) independent variables: gender, mathematical ability, ICT literacy, and language skills. The research subjects were 34 2017 Unesa Information Technology Education undergraduate students who had taken Mathematics, Indonesian Language and Introduction to Information Technology courses.

Data collection is done by giving Mathematics tests, understanding concepts and ICT applications, and Indonesian Language. The test given is in the form of an essay. The test has been validated by an expert and is declared suitable for use. While the level of computational thinking skills is obtained by giving a project about two-dimensional animation to be done using the block-based programming language, Scratch. The project that has been done is assessed using Dr. Scratch (www.drscratch.org) is a device to assess the level of computational thinking based on the Scratch project that has been created. Feedback given by Dr. Scratch is the classification of computational thinking based on Resnick's theory of flow control, data representation, abstraction, user interactivity, synchronization, parallelism, and logic.

The data analysis used in this study is multiple linear regression which is written mathematically as follows.

$$Y = \alpha + \beta 1X1 + \beta 2X2 + \ldots + \beta 1Xn + €$$

where,

Y	= the criteria variable which is the level of computational thinking skills
X1, …, Xn	= independent predictor variables are gender, mathematical ability, ICT literacy, and language skills
α	= constant

$\beta 1, \beta 2$ = regression coeffisient
€ = error

4. Results and Discussions

4.1. Effect of gender on the level of computational thinking skills

The results of linear regression tests performed for the first case using SPSS are formulated as follows.

$$Y = 15{,}40 - 0{,}483X_1$$

where Y is the level of computational thinking skills and X_1 is gender.

The constant number of unstandardized coefficients is 15.4 and the regression value is minus. It thus can be concluded that female students have higher computational thinking ability than male students. Next, hypothesis testing is done to analyze whether the regression coefficient is significant. The hypothesis proposed for this case is:

H0: There is no gender effect (X_1) on the level of computational thinking skills (Y)
H1: There is effect of gender (X_1) on the level of computational thinking skills (Y)

The significance value is greater than the probability of 0.05. This means that H0 is accepted. In other words, there is no significant effect between genderes on the level of computational thinking skills. The R square value is 0.011. This means that the effect of gender (X_1) on the level of computational thinking skills (Y) is 1.1% while 98.9% is effectd by other variables.

4.2. Effect of mathematical ability to the level of computational thinking skills

The results of linear regression tests were carried out for the second case using SPSS is formulated as

$$Y = 13{,}309 + 0{,}5X_2$$

where Y is the level of computational thinking skills and X_2 is mathematical ability.

The constant number of unstandardized coefficients is 13.309 and the regression value is positive. It can be determined that the higher students' mathematical ability the higher level of computational thinking skills. Afterward, hypothesis testing is performed to analyze whether the regression coefficient is significant. The hypothesis proposed for this case is:

H0: There is no effect of mathematical ability (X_2) on the level of computational thinking skills (Y)
H1: There is an effect of mathematical ability (X_2) on the level of computational thinking skills (Y)

The significance value is 0.001 or smaller than the probability of 0.05. This means that H0 is rejected and H1 is accepted. In other words, there is a significant effect between mathematical abilities on the level of computational thinking skills. The R square value of 0.361. This means that the effect of mathematical abilities (X2) on the level of computational thinking skills (Y) is 36.1% while 63.9% is effectd by other variables.

4.3. Effect of ICT literacy on the level of computational thinking skills

The results of linear regression tests were carried out for the third case using SPSS is:

$$Y = 14{,}633 + 0{,}153X_3$$

where Y is the level of computational thinking skills and X_3 is ICT literacy.

The results of linear regression tests were carried out for the third case using SPSS. The constant number of unstandardized coefficients is 14,633 and the regression value is positive, it can be concluded that the higher the ICT literacy of students, the higher the level of computational thinking skills. Next, hypothesis testing is done to analyze whether the regression coefficient is significant. The hypothesis proposed for this case is:

H0: There is no effect of ICT literacy (X_3) on the level of computational thinking skills (Y)
H1: There is an effect of ICT literacy (X_3) on the level of computational thinking skills (Y)

The significance value is 0.677 or greater than the probability of 0.05. This means that H0 is accepted. In other words, there is no significant effect between ICT literacy on the level of computational thinking skills. The R square value of 0.05. This means that the effect of ICT literacy (X_3) on the level of computational thinking skills (Y) is 0.5% while 99.5% is effectd by other variables.

4.4. Effect of language skills on the level of computational thinking skills

The results of the linear regression test performed for the fourth case is formulated as follows.

$$Y= 12{,}742 + 0{,}628X_4$$

where Y is the level of computational thinking skills and X_4 is language skills.

The constant number of unstandardized coefficients is 12.742 and the regression value is positive. It means that the higher the students' language skills the higher level of computational thinking skills. Then, hypothesis testing is achieved to analyze whether the regression coefficient is significant. The hypothesis proposed for this case is:

H0: There is no effect of language skills (X_4) on the level of computational thinking skills (Y)
H1: There is an effect of language skills (X_4) on the level of computational thinking skills (Y)

The significance value is 0.003 or smaller than the probability of 0.05. This means that H0 is rejected and H1 is accepted, this is to say, there is a significant effect between language skills on the level of computational thinking skills. The R square value of 0.372. This means that the effect of ICT literacy (X_4) on the level of computational thinking skills (Y) is 37.2% while 63.8% is effectd by other variables.

4.5. Effect of gender, mathematical ability, ICT literacy, and language skills together on the level of computational thinking skills

Furthermore, the effects of gender, mathematical ability, ICT literacy, and language skills will be tested together on the level of computational thinking. Based on the regression test results shown in Table 1, the regression formula is obtained as follows.

$$Y = 13{,}843 – 0{,}391X_1 + 0{,}489X_2 + 0{,}088X_3 + 0{,}459X_4$$

where,

Y = level of computational thinking skills
X_1 = gender
X_2 = mathematical ability
X_3 = ICT literacy
X_4 = language skills

Table 1. The regression test results of effect all variables together on computational thinking skills

Coefficients[a]					
		Unstandardized Coefficients		Standardized Coefficients	Sig.
Model		B	Std. Error	Beta	
1	(Constant)	13.843	8.849		.129
	Gender	-.391	.984	-.086	.069

	Mat	.489	.013	.038	.008
	ICT	.088	.532	.042	.087
	Bahasa	.459	.079	.015	.009
a. Dependent Variable: CT					

Based on Table 1, it can be decided that gender and ICT literacy do not have a significant effect on the level of computational thinking skills.

5. Conclusions

Based on the analysis results, it can be concluded that the level of computational thinking sequentially is effected by mathematical abilities, language skills, gender, and ICT literacy. However, the most effective variable in predicting the level of computational thinking skills is mathematical ability. This finding is in line with research conducted by previous researchers. For further research, a larger amount of data shoul be performed to attain the results more accurate in measuring and adding other variables such as student learning styles.

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