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Beginner Programmer Predictions with Timss and AQ Assessments

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For some students of Vocational High School, programming is a difficult subject to master. It is due to the mismatch between the interests and cognitive abilities of students when joining recruitment for the Study Program of Computer & Informatics Engineering. The research is quantitative by correlating the TIMSS and AQ variables with programming skills. The research sample is all vocational high schools, which have a Study Program of Computer & Informatics Engineering in Lahat Regency, Indonesia. The sample started to get TIMSS and AQ assessments at the beginning of the semester of grade X, and the assessment of programming skills was given after they took part in learning for 1 semester. The results prove there is a significant relationship between the TIMSS and AQ variables on the programming skills variable. Both variables can also predict their programming abilities.

Key words: *Novice programmer, Assessment, TIMSS, Adversity Quotient.*

Introduction

Programming is a compulsory subject in the program of Computer and Informatics Engineering for some Vocational High Schools. Based on the results of empirical studies in five schools that have basic programming subjects, student test results are still far below the standard. Their difficulties in learning basic programming include 1) variables, data types, relatively easy constants; 2) the moderate selection and condition ; 3) repetition of difficult categories; 4) variable indexes/arrays that are difficult and cause the algorithm to fall into a difficult category.

In several countries, developing computational and algorithmic thinking in students is currently the primary goal of primary and secondary education (Vrachnos & Jimoyiannis, 2017), (Sellars, 2017). Programming learning is a cognitive activity relying on reasoning skills (Barker & Unger, 1983), understanding and technical skills (Zhou, Li, Deng, & Li,

2019). Computer programming is a difficult subject, yet very useful in the future. Skills are one of the factors that directly affect student performance, as well as programming skills. This capability requires individual knowledge effectively and ready in completing programming tasks. Besides, motivation and knowledge also have the same role in determining students' abilities (Bergersen, Sjøberg, & Dyba, 2014).

Some literature and research attest that programming categorized as one of the difficult subjects for students at the beginning of their school semester. Discussion of some previous research on students' abilities on programming subjects for beginners also states, programming is one of the difficult subjects for students, especially for beginners (Raadt, 2008); (Law, Lee, & Yu, 2010); (Joseph, Hunsinger, & Wu, 2015); (Wang & Hwang, 2017) (Güney, 2019). Previous studies are in line with the experience of the researchers who also had difficulty to teach basic programming for vocational high school students.

The research study on computer learning emphasizes the need to examine students' cognitive maturity and their learning styles. The study found students' academic success in computer programming is related to cognitive maturity and learning styles (White & Sivitanides, 2009). This factor is still often overlooked in studies aimed at determining factors of academic success at the tertiary level. Other studies (Almstrum, 1994; Cafolla, 1987 in (White & Sivitanides, 2009) answer why some students who take learning computer programming often experience failures, while some other students succeed in mastering it. The results show that fresh students of computer science are more struggles with concepts involving mathematical logic, compared to understanding other concepts.

Student assessment, success analysis, and difficulty are the first steps in the process of improving student performance because they highlight key aspects of student learning processes (Wijaya et al, 2019). After diagnosing students' learning difficulties (Tall & Razali, 1993), they recommend providing good and correct learning strategies. Students who experience learning difficulties do not only need the help of specific strategies to overcome the mistakes they make. For fresh students of vocational high school (grade X of High Vocational School), we cannot determine their reasoning ability by giving questions related to programming, because they have never studied computer programming. Therefore, there must be an assessment tool to predict their abilities.

Some standard assessment tools to measure learning success and learning difficulties, one of them, is (Jamaris, 2015) 1) intelligence test. The test is useful for measuring a children's level of intelligence before determining them as children who experience learning difficulties; 2) achievement test such as Woodcock-Johnson Psycho-Educational Batery, is one of the standard tests to measure the ability of individuals aged 3 years to 80 years (Kaufman, Reynolds, Liu, Kaufman, & McGrew, 2012). The Peabody Individual Achievement Test is to

measure cognitive abilities and learning outcomes of individuals aged 6 to 60 years (Bartels, 1999). Wide Range Achievement Test (WART) is adopted to measure the ability of individuals aged 3 years to 74 years, especially to measure the ability to read, do arithmetic/mathematics (Jant et al., 2015). The Woodcock Reading Mastery Test is useful for measuring reading ability of students aged 6 years to 11 years old (Pae et al., 2005). Keymath Diagnostic Arithmetic Test aims to measure the strengths and weaknesses of individuals in mathematics, especially those related to arithmetic (Eaves & Simpson, 1984). The Test of Written Language (TOWL) measures the written and language skills of individuals aged 7 to 18 years (Hresco & Austin, 1990).

TIMSS (Trends in International Mathematics and Science Study) is a measure of the ability of fourth, eighth and final grade students in mathematics and science. The latest series of TIMSS is TIMSS 2019. Teaching processes began with the first assessments in 1995 and continued every four years - 1999, 2003, 2007, 2011, 2015, and 2019. About 60 countries had used TIMSS data to monitor the effectiveness of their education systems in 2015 (Lindquist, Philpot, Mullis, & Cotter, 2019). In 2019, about 70 countries also applied this method. The TIMSS assessment focuses on measuring 3 (three) cognitive domains, namely knowing 35%, applying 40%, and reasoning 25% (Lindquist et al., 2019).

Adversity Quotient is the ability or intelligence of an individual to overcome obstacles and difficulties (Stoltz, 1997) in life. Stoltz grouped AQ into three categories, namely low AQ - called quitter, medium AQ - called camper, and high AQ - called climber. Quitters are a group of people who have a low willingness to face problems and challenges in their lives. Campers are people who already have a strong will in facing challenges and problems, but they try to avoid the problems. They feel insecure and unable to solve the problem. Climbers are groups of people who choose to continue to fight and face various kinds of things in their life, whether it can be problems, challenges, obstacles, and other things (Fauziyah, Usodo, & Henny, 2013; Vinas & Aquino -Malabanan, 2015).

This study does not only focus on cognitive abilities assessment but also looks at students' soft skills (Seal, 2019). In contrast to some studies conducted by researchers such as (Hettiarachchi, Mor, Huertas, & Guerrero-Roldán, 2015) that use formative assessment of programming, (Crisp, 2011) (Hettiarachchi, Huertas, & Mor, 2015) choose the development of skills and cognitive programming. The assessment in this study aims to obtain a measuring tool to predict the success of students becoming a programmer at the beginner level. This assessment examines the reasoning abilities in the form of arithmetic and algebraic abilities tests using tasks from TIMSS, as well as students' abilities and intelligence in surmounting difficulties called Adversity Quotient (AQ).

Understanding the successes and failures of students is the first step in managing the appropriate treatment to improve their learning outcomes. Important questions answered through this research are 1) Can the numerical ability of students predict the success of beginner programmers in making programs ?; 2) Can AQ students predict the success of beginner programmers in making programs ?; 3) Can the numerical ability and AQ together predict the success of beginner programmers in making programs? This study is expected to gather necessary information about the variables defining student success in learning programming. The findings variables are useful as assessment variables in prospective Vocational High School students who choose Computer and Informatics Engineering study programs.

Method

This study works to determine the effect of TIMSS and AQ ability variables in predicting the programming abilities of vocational school students who are just beginning to learn about programming (beginners). The TIMSS tasks in the assessment are adjusted to fit the cognitive level of fresh vocational students.

Table 1: List of TIMSS Materials and Measurement Domains

No	Material	Domain	Tasks
		Knowing	5
1	Measurement and Geometry	Applying	6
		Reasoning	4
		Knowing	7
2	Number	Applying	4
		Reasoning	4

TIMSS tasks consisted of 2 (two) materials, namely measurements, geometry, and numbers. The composition of tasks for each domain was knowing of 12 items, applying of 10 items, and reasoning of 8 items. Before tested on students, the questions were inquired to see their validity and reliability. The researchers used SPSS to examine it. The trial results confirm the value of Cronbach's Alpha Based on Standardized Items of 0.802. The validity of the questions gets the value of Corrected item-total Correlation of 0.435 to 0.633. The items are declared valid and reliable at a 5% significance level with N = 31 R_{table} of 0.355 (Hidayat, 2013).

Variable AQ contains a questionnaire tested for validity and reliability with indicators stated in the following table 2 (Shen, 2014; I. G. H. Wijaya, Agustini, & Darmawiguna, 2017):

Table 2: Indicators of variable AQ in Programming

No	Indicator	Information
1	Control	Individuals can control the difficulties
2	Origin and Ownership (O2)	The cause of the difficulties and responsibilities to overcome these problems An individual considers himself to influence himself as the cause of the origin of problems.
3	Reach	The ability to make judgments about stressful workloads, the effect of difficulties on our self
4	Endurance	Not easily give up, the ability of individuals to overcome frustration in solving problems

The validity testing of instrument items is at a significant level of 5% with N = 31, R_{table} 0.355. Based on the test results, after 3 revisions and trials, all the instruments tested are already in the valid category; all grades of *Corrected Item-Total Correlation* > 0.355. The Reliability Statistics value, on Cronbach's Alpha Based on Standardized Items is 0.772> 0.355. The instruments to be used are reliable (Hidayat, 2013).

The population was all new students of grade X of vocational schools in Lahat Regency who had a Computer and Informatics Engineering study program. The sampling technique was probability. This Simple Random Sampling technique was chosen so that the sample truly represented the population (Creswell, J, 2015). The total population was 202 students, and the number of samples at an error rate of 5% was 133 (Sugiyono, 2015). The maximum age of the sample was 15 years. The study population and sample are explained in table 3:

Table 3. Population and Research Samples

No	School name	The number of students of Grade X	Number of Samples
1	Vocational High School 1 Lahat	60	41
2	Vocational High School 2 Lahat	32	21
3	Vocational High School 3 Lahat	32	21
4	Vocational High School PGRI 2 Lahat	47	29
5	Abdurrahman Vocational High School	31	21
	Total	202	133

The data were collected using documentation techniques citing student responses in the AQ questionnaire; TIMSS test results, and Basic Programming learning outcomes.

The researchers gave TIMSS tasks and the Adversity Response Profile questionnaire to fresh students in the Computer and Informatics Engineering study program. They had to work on the problems and answer the questionnaire given. Basic Programming learning outcomes were attained after conducting the learning process for 1 semester and semester II run in March 2020. In that period, the Basic Programming subject matter had arrived at the Array material. In the current semester, students were expected to master the basics of programming. Hence, the measurement of ability to the Array material could already be carried out. The research study has dependent variables such as the ability of TIMSS (X1), and AQ (X2), while the independent variables are the learning outcomes of the Basic Programming (Y).

The study recommends the hypothesis H0, which has no relationship between TIMSS ability and beginner programming skills. H1 has a relationship between TIMSS ability and programming skills for beginners. The hypothesis for the second question are H0 - there is no relationship between AQ ability and beginner programming skills, and H1 that has a relationship between AQ ability and beginner programming skills. The hypothesis for the third research question of H0 states there is no relationship together with the ability of TIMSS and AQ to beginner programming skills. H1 has a relationship together with the ability of TIMSS and AQ to beginner programming skills. To answer the first and second research questions, the researchers applied a linear regression of each dependent variable to the independent variable. To answer the third question, researchers utilized multiple linear regressions X1 and X2 together against the Y variable. The research paradigm is explained as in Figure 1 below:

Figure 1. Relationship Between Variables X1, X2, and Y.

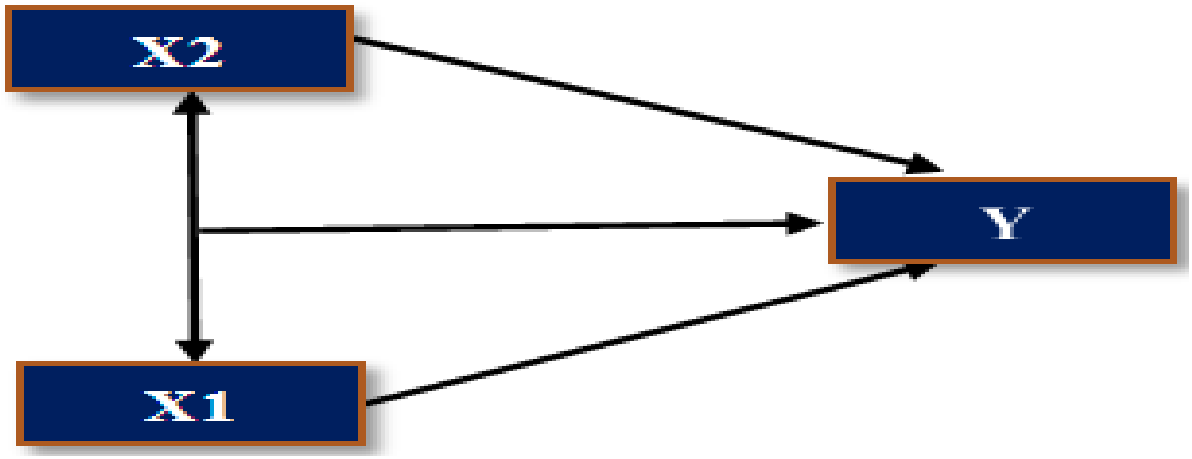

Figure 1 explains the occurrence of the relationship between the variables X1 to the variable Y, the variable X2 to Y, and together X1, X2 to the variable Y.

Results and Discussion

The assessment was conducted at 5 Vocational High Schools in Lahat Regency, South Sumatra Province. The samples were collected randomly with the number as explained in the research method. The results of the TIMSS assessment, programming skills, and AQ questionnaire conducted on the sample are presented in table 4 below:

Table 4: TIMSS assessment scores, programming abilities, and AQ

Score	TIMSS	AQ	Programming
0 - 20	15	0	28
21 – 40	43	0	48
41 – 60	49	61	36
61 – 80	23	70	20
81 – 100	3	2	1
Total	133	133	133

Before conducting a regression analysis in each variable, the researchers firstly implemented the normality analysis, linearity analysis, and multicollinearity analysis. The analyzes were to see the variables X1 with Y, and X2 with Y with the SPSS application. The analysis results are presented in table 5.

Table 5: Test for Normality, Linearity and Multicollinearity

Analysis	(X1 with Y)	(X2 with Y)
Normality: Kolmogorov-Smirnov Unstandardized residual, Asiymp.Sig (2 Tailed)	0.2	0.2
Linearity: Deviation of linearity (F)	1.466	1.454
Deviation of linearity (Sig.)	0.99	0.087
Multicollinearity:	0.665	0.665
Collinearity Statistics – Tolerancy		
Collinearity Statistics - VIF	1.504	1.504

Based on the results of Kolmogorov-Smirnov analysis, the value of Asiymp.Sig (2 Tailed) for X1 with Y is 0.20 and between X2 and Y Asiymp.Sig (2 Tailed) is 0.20. The data is normal if the Asiymp.Sig (2 Tailed) value is greater than 0.05 (Raharjo, 2014a). For the

linearity, the analysis can be seen in the Definition of linearity (Sig.). If the value exceeds 0.05, the data is linear. In table 5 shows the Definition of linearity (Sig.) for X1 with Y of 0.99, and X2 with Y of 0.087. Both values are greater than 0.05. The data has met the linearity (Raharjo, 2014a). Multicollinity analysis check the value of Collinearity Statistics - Tolerance and Collinearity Statistics - VIF to determine conclusions. Collinearity Statistics - Tolerance value must be greater than 0.10. Collinearity Statistics - VIF value must be less than 10.00 (Raharjo, 2014b). The Collinearity Statistics - Tolerance value for variables X1 and X2 is 0.665, and the VIF value is 1.504. According to the results of the analysts in table 4, all variables meet the test requirements so that multiple regression analysis can be preceded.

To answer the first question and the first hypothesis of the study, the sample was tested by finding the correlation between the two variables and arranging a simple regression analysis. The calculation proves the contribution of variable X1 to variable Y. The correlation analysis using SPSS is as presented in table 6.

Table 6: Correlation of variables X1 and Y

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.588[a]	.345	.340	15.694

On table 6, the correlation between X1 and Y is 0.588. The results of the analysis reveal the correlation occurred between variables lies in the medium category (Schober & Schwarte, 2018).

To test the hypothesis H0 - there is no significant relationship between variables X1 and Y, H1 - there is a significant relationship between variables X1 and Y, it can be seen in table 6 ANOVA analyses between variables X1 and Y.

Table 7: Analysis of ANNOVA X1 and Y

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	17019.293	1	17019.293	69.104	.000[b]
	Residual	32263.534	131	246.287		
	Total	49282.827	132			

Based on table 7, the F_{value} is 69,106. To assure the hypothesis is accepted, the F_{count} value of 69.104 in table 6 is compared with the F_{table} value. The F_{value} of the table is 3.065. If $F_{value} > F_{table}$ then the X1 variable has a significant relationship to the Y variable. If Sig. (0.00) $<\alpha$ (0.05) then H1 is accepted and H0 is rejected. The results of the analysis in table 6 present the correlation coefficient is significant (Hidayat, 2012).

Regression equation predicting the value of beginner programming skills with TIMSS or Y assessment ability for X1 is the formula of $\hat{Y} = a + bX1$ (1). $\hat{Y}$ is the beginner programming skills, a is a constant, X1 is the independent variable of TIMSS assessment results, and b is the regression coefficient. To obtain the coefficient on the regression plan This study used the SPSS application. The analysis results are presented in table 8 of ANOVA and Coefficients.

Table 8: ANOVA and Coefficients

Unstandardized Coefficients				Standardized Coefficients		
Model		B	Std. Error	Beta	t	Sig.
1	(Constant)	11.769	3.833		3.070	.003
	TIMSS (X1)	.663	.080	.588	8.313	.000

In table 8, the value of a = 11.769, b = 0.663, so the regression equation: $\hat{Y} = 11.769 + 0.663X1$ (2). The result of significance testing of the regression coefficient Y to X1 is H0, which the regression coefficient is not significant. The regression coefficient of H1 is significant. The hypothesis was examined by looking at the results of the analysis for the t_{value}. From table 8, the t_{value} is 8.313. If t_{value} (8,313)> from t_{table} (1.97824) then the regression coefficient is significant. Significance testing criteria at the 0.05 level, if Sig. > α (0.05), the Ho is rejected. If Sig. <α (0.05), then H1 is accepted. The significant level in table 8 is 0.00 <0.05, then H1 is accepted; the regression coefficient is significant.

To answer the second question and the second hypothesis, the researchers tested the correlation between the variables X2 and Y and calculated the X2 variable to see its contribution to the Y variable with a simple regression equation. Correlation analysis using SPSS is as presented in table 9.

Table 9: Correlation of variables X2 with Y

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.537[a]	.345	.289	16.357

Based on table 9, the correlation between X2 and Y is 0.537. The results of the analysis indicate the correlation occurred between variables is in the medium category.

To test the hypothesis H0, which has no significant relationship between variables X2 and Y, and H1 that has a significant relationship between variables X2 and Y, it can be seen in table 10 and ANOVA analysis between variables X1 and Y.

Table 10: Analysis of ANOVA X2 and Y

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	14232.698	1	14232.698	53.195	.000[b]
	Residual	35050.129	131	267.558		
	Total	49282.827	132			

Table 10 shows an F_{value} of 53,195. To check the accepted hypothesis, the calculated F_{value} of 53.195 in table 9 is compared with the F_{table} value of 3.065 (Hidayat, 2012). If $F_{value} > F_{table}$, then the X2 variable has a significant relationship to the Y variable. If significant Sig. 0.00 <α (0.05), the H1 is accepted and H0 is rejected. The significant level in table 9 is 0.00 <0.05, then H1 is accepted; the correlation coefficient is significant.

Regression equation to predict the value of beginner programming skills through the results of the AQ or Y assessment of X2 use the formula of $\hat{Y} = a + bX2$ (3). To obtain the coefficients in the regression equation, the data were analyzed using the SPSS application. The analysis results are presented in table 11 ANOVA and Coefficients.

Table 11: ANOVA and Coefficients

Unstandardized Coefficients				Standardized Coefficients		
Model		B	Std. Error	Beta	T	Sig.
1	(Constant)	-32.225	10.215		-3.155	.002
	AQ (X2)	1.190	.163	.537	7.293	.000

Table 10 shows the value of a = -32.225, b = 1.190, so the regression equation becomes, $\hat{Y} = -32.225 + 1.190X2$ (4). The significance testing of the regression coefficient Y against X2 is H0, which the regression coefficient is not significant. H1 has a significant regression coefficient. Table 11 shows the calculated t_{value} of 7.293. If t_{value} (7.293) > from t_{table} (1.97824), the regression coefficient is significant. Criteria of significance testing at the level of 0.05, if Sig. > α (0.05), then Ho is rejected. If Sig. <α (0.05), then H1 is accepted. The significant level in table 11 is 0.00 <0.05, H1 is accepted; the regression coefficient is significant.

To answer the third question, researchers used multiple linear regressions on the variables X1, X2 together with the Y variable. Before moving on to the multiple regression analysis, it is esensial to pay attention to the correlation analysis presented in Table 12 below:

Table 12: Correlation of variables X, X2 to Y

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.635[a]	.404	.395	15.034

According to table 11 the correlation of X1, X2 together with Y is 0.635. The results of the analysis determine the correlation is in the medium category. Table 12 illustrates the correlation of variables X1, X2 together with Y variables.

Hypothesis testing of H0 - has no significant relationship between variables X1, X2 together with Y, and H1- has significant relationship between variables X1, X2 together with Y can be seen in table 13, ANOVA analysis between variables X1, X2 with Y.

Table 13: Analysis of multiple linear regression ANOVA variables X1, X2 to Y

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	19900.886	2	9950.443	44.026	.000[b]
	Residual	29381.941	130	226.015		
	Total	49282.827	132			

Table 13 gets an F_{value} of 44,036. To see the accepted hypothesis, the calculated F_{value} of 53,195 in table 9 is compared with the table's F_{value} of 3,065. If $F_{value} > F_{table}$ then the variables X1, X2 have a significant relationship to the variable Y. On a significant Sig. 0.00 $<\alpha$ (0.05), H1 is accepted and H0 is rejected, which means the correlation coefficient is significant.

Regression equation to predict the value of beginner programming skill through the TIMSS, AQ assessment results together (Y against X1, X2) uses the formula of $\hat{Y} = a + b1X1 + b2X2$ (5), $\hat{Y}$ is a beginner programming skills, a is a constant, X1 is the result of TIMSS assessment, X2 is the result of AQ assessment, b1 is the 1st regression coefficient and b2 is the 2nd regression coefficient. To obtain the coefficient on the regression equation, the researchers analyzed the data using the SPSS application. The results are presented in table 14 ANOVA and Coefficients.

Table 14: ANOVA and *Coefficients*

Unstandardized Coefficients				Standardized Coefficients		
Model		B	Std. Error	Beta	t	Sig.
1	(Constant)	-20.245	9.689		-2.090	.039
	TIMSS (X1)	.469	.094	.416	5.008	.000
	AQ (X2)	.657	.184	.297	3.571	.000

From table 14, it forms a regression equation: $\hat{Y} = -20.245 + 0.469X1 + 0.657X2$ (6). The significance testing of the regression coefficient Y against X1, X2 is H0 - the regression coefficient is not significant. H1 has a significant regression coefficient. Table 14 illustrates the calculated t_{value} for variable X1 of 5.008. If t_{value} (5.008) > from t_{table} (1.97851), the regression coefficient is significant. For the calculated X2 variable t (3,571) > t_{table} (1.97851), the regression coefficient is also significant. Significance testing criteria at the 0.05 level, if Sig. > α (0.05), Ho is rejected. If Sig. <α (0.05), then H1 is accepted. The significant level in table 12 for both variables X1 and X2 is 0.00 <0.05, H1 is accepted and the regression coefficient is significant.

The coefficient of determination R Square (R2) of the TIMSS variable is equal to 0.345. It means the close value of the relationship between the TIMSS variable with the variable programming skills is 0.345 or 34.5%. The effect of other variables on programming skills is 65.5%. The coefficient of determination R Square (R2) for the AQ variable is 0.289 or 28.9%. The closeness of the relationship between the AQ variable with programming skills is 28.9%, the rest is influenced by other variables. The coefficient of determination R2 together for both TIMSS and AQ variables is 0.404 or 40.4%. Both variables influence programming skills by 40.4%, the rest is influenced by other variables.

Table 6, table 9, and table 12 present the correlation between X1 and Y, X2 with Y, X1, X2 together with Y including those in the medium category (Schober & Schwarte, 2018). The figures obtained from the correlation analysis are between 0.537 for variables X2 with Y, 0.588 for X1 with Y, and X1, X2 with Y for 0.635. The correlation value indicates the independent variables affect the student's programming skills. This finding is in line with the previous research study, which affirms numerical ability is one of the predictors in supporting the programming skills (Barlow-Jones & van der Westhuizen, 2017) (Kerr & Danino, 2018). For variable X2, the correlation is slightly below variable X1. There is no research found associating AQ to be one of the predictors in programming. The variable part of AQ in the form of perseverance and not easily giving up is a part of the factors of programming success (Prastianto, 2016) (Poole, Saigal, Van Lieshout, & Schmidt, 2019).

Conclusion

Programming skills challenge cognitive abilities and good reasoning skills. Students in vocational schools who get Computer and Informatics subjects are often unable to master programming learning well. The assessment in this study does not only focus on the assessment of cognitive abilities but also on the students' soft skills. This research study found the assessment using TIMSS and AQ can predict the level of programming skills for beginner or grade X students of Vocational High Schools. The results of this study also

explain there are still other variables that may contribute to predicting programming skills for beginners.

Recommendation

The research results can predict 40.4% of beginner programming skills, but it still needs to examine other variables to complete them. If the future researchers are going to assess students who are over the age, with the different cognitive maturity, surely the questions are adjusted to different levels of difficulty and complexity.

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