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The Effectiveness of Worksheet Based Learning of Rotational Dynamics on Students' Critical Thinking Skills Viewed from IQ Score

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Abstract

The aim of this study is to find out and analyze the effect of a worksheet based learning of rotational dynamics on students' critical thinking skills viewed from IQ score and the correlation between critical thinking skills and the students' IQ score. This research has been conducted in even semester of the academic year of 2017/2018, in university in Bandung area. All students in a university in Bandung City are the population for this study with the target population are all students in the first year in the university year of 2017/2018. The sample in this study is the first semester of Physics Education students as an experimental group, selected using purposive sampling technique, with data collecting tool in the form of written test of critical thinking skill and IQ. The research design used is one shot case design. A hypothesis test is done by using correlation and regression. The whole test of this data analysis used SPSS program. The results of this study indicate that the learning-based student's worksheet on the concept of Rotational Dynamics significantly influences students' critical thinking skills. It can be seen from the score of n-gain which is 0.5. Based on the calculation on correlation obtained value of 0.185 <0.5, it means that IQ scores correlated weakly to the students' critical thinking score, while the regression value of 0.303> 0.05, in other words, the students' IQ score does not affect the students' critical thinking skills. So it can be concluded that there is no correlation between IQ and critical thinking skills which seen from the results of correlation and regression analysis.

1. Introduction

Physics has a close relationship with the phenomenon of everyday student life (Gupta, Hammer, & Redish, 2010). Through many phenomena related to physics, it will surely become a stimulus for students to grow their critical thinking skills about the experienced events directly or see the phenomena related to the concept of physics (Firdaus & Sinensis, 2017; Ramos, Dolipas, & Villamor, 2013; Rokhmat, 2017). The implementation of the basic course of physics at the university is a means to train students to be able to master the concept of physics and have critical thinking skills. Hence, by studying basic physics course, students' critical thinking skills can be also developed (Hill, Sharma, & Johnston, 2015; Tiruneh, De Cock, Weldeslassie, Elen, & Janssen, 2017). Furthermore, in every learning instruction at university, students' critical thinking skills need to be trained.

The classroom instruction can not be separated from the role of an educator to find a concept. Lecturers need to guide and direct students toward the discovery of the concept (Mulhayatiah, Suhendi, & Oktaviani, 2017). In line with the statement, Chusni et al. (2017) argue that an educator must master the four basic competencies one of which is, professional competence, where a teacher must be able to do lesson planning, instruction and learning evaluation. Some of the learning methods that can be applied to find a concept are demonstrations, image and video presenting, or direct experiments conducted by educators where learners are positioned as if a scientist who performs a process of connecting between the appeared phenomena the concepts studied (Suhendi et al., 2014). These activities require a learning media; one of the learning media that can be used is teaching materials. The MFI is one of the teaching materials (Adnyawati, 2011). Fatimah, et al. (2014) revealed that worksheets are students' manual book used for investigation or problem-solving activities during the learning instruction. Worksheets should be made by the lecturers, and adapted to the syllabus they made. Instead, worksheets are now not collections of questions but steps of learning activities undertaken by students to build their knowledge, which may be questions or practices (Redhana, 2013, Saregar, 2016). However, due to the lack of commitment among lecturers in applying the existing curriculum and the unwillingness of the lecturers to make the worksheets, make the publishers take the advantage of the situation so that publishers who take the action to make the worksheets and offer them to universities. As a consequence, the teaching materials in the form of worksheets are far from the objectives achieved by curriculum.

Generalization of students' thinking skills is often done by lecturers, but in the reality,the students achieved differently. Consequently,the lecturers hold a remedial to upgrade the score based on the standards that must be achieved. The process for knowing the characteristics of students who have remedial can be analyzed based on IQ (Intelligence Quotient). The above statement is in line with some researchers' arguments (Bakhiet, Haseeb, Seddieg, Cheng, & Lynn, 2015; Golsteyn & Schils, 2014).They argue that most of the students who fail in the course are affected by their IQ.

This research has the main objective to know the effect of worksheet teach rotational dynamics on students'critical thinking skills based on intelligence classification so that it can be seen which effect dominates the students' critical thinking skill from the learning activity using worksheet of rotational dynamics.

2. Method

This research was conducted in the even semester of academic year 2017/2018, at one university in Bandung City, West Java. This research uses an experimental method where the steps of the research are divided into three stages; the first stage, the implementation stage, and the final stage.

One group pretest postest design is a research design applied by the researcher. This research design is selected because the researcher wants to involve one research group only (Fraenkel, Wallen, & Hyun, 2012), where the experiment group were chosen purposively. Such sampling is applied because the researcher uses personal considerations to select the sample (Creswell & Creswell, 2017). Researchers consider that the sample taken is representative of the population. The test in the form of an essay is a test instrument applied in this study; thetest consists of nine questions as the adaptation of eight indicators of critical thinking skillsproposed by Robert H. Ennis (Ennis, 2011), which provides a simple explanation (formulating questions), making summaries, giving simple explanations, mentioning examples, building basic skills (reasoning skills), summing up hypotheses, giving further explanations (making content definitions), setting up strategies and tactics (using arguments). Another instrument is in the form of student response questionnaire using a Likert scale. The hypothesis test of this research adopted correlation and regression test, because researcher wanted to see the correlation and the interrelations between variables. At last,all data are analyzed using SPSS program.

3. Result and Discussion

The results of this study focused on finding out the effect of a worksheet based learning to teach Rotational Dynamics on students' critical thinking skills reviewed from IQ classification, and the correlation between critical thinking skills and students' IQ. The treatment is given in three meetings with different concept scope. To see how effective the treatment is, the researcher applied N-Gain (Normalized Gain). The average N-Gain score of all samples is interpreted as an improvement of critical thinking skills as the impact of worksheet of rotational dynamics based learning. The description of improvement of critical thinking skills can be seen in Table 1 below:

Table 1. The Score of*Pretest, Posttest* and N-Gain for each critical thinking skill indicator

No	Indicator	*Pretest*	*Posttest*	N-Gain	Category
1	Formulating Question	52	72	0,47	Middle
2	Giving simple explanations	30	68	0,54	Middle
3	Summarizing	57	86	0,64	Middle
4	Mentioning samples	53	89	0,67	Middle
5	Reasoning	49	77	0,42	Middle
6	Making Content Definition	48	72	0,42	Middle
7	Summing up hypothesis	42	73	0,48	Middle
8	Presenting Argument	33	55	0,21	Low
	Mean	45	74	0,50	Middle

The diagram about the average percentage of N-gain improvement for each indicator of critical thinking skills can be seen in Figure 1 below:

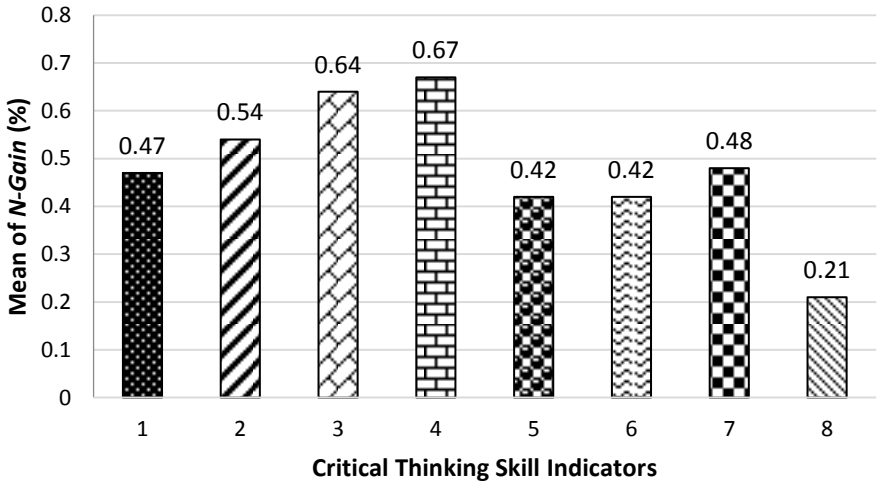

Figure 1. The Percentage of*N-Gain* mean for each critical thinking skill indicator

Table 1 and Figure 1 show N-gain results on each indicator where the largest N-gain of the eight critical thinking skills indicator is the fourth indicator with 0.67 N-gain scores on the indicator:giving example; the second largest score with 0.64 N-gain score on the third indicator: summarizing; the third largest score with 0.64 N-gain score on the indicator: giving a simple explanation; the N-gain score about summing up the hypothesis is 0.48; the N-gain score of formulating questions and making the definition equal to the score of 0.47; and presenting argument N-gain score is 0.21 with low category. Of the eight indicators, only one got lowest score namely presenting arguments, perhaps this task is quite difficult for students to do.

The students 'critical thinking skills from the pretest result have not been seen yet, but at the last meeting, the students' critical thinking skills begin to reveal after being given posttest

treatment. Of the eight indicators of critical thinking skills, the highest is on the indicators mentioning the example. Students are able to provide simple examples related to daily life regarding the materials of rotational dynamics and balance of rigid bodies. Through the learning instruction that occurs on teaching materials using worksheet, it provides critical thinking skills tests (with pretest and posttest) which can be used as an effort to train students in improving critical thinking skills (Sofiatin, Azmi, & Roviati, 2016). This is in line with Ritdamaya & Suhandi (2016) who argued that critical thinking skills can be applied, trained and developed through learning instruction and assessments. Teachers act as mediators and facilitators, and apply methods, models or strategies that can train and develop students' critical thinking skills in the learning instruction (Hariri, Kartimi, & Mulyani, 2016; Rahmah, Lesmanawati, & Wahidin, 2015; Jaelani, Wahidin, & Roviati, 2016; Sari, Kartimi, & Fitriah, 2015). Meanwhile, the lowest N-gain score of the critical thinking skill test is an indicator of presenting an argument with N-gain 0.21. Judging from the students' answer about the indicator, the student found difficulties in expressing the argument about phenomenon problem.

The result of pretest and posttest conducted by students, got result of N-gain as big as 0,50 with medium category. The score of N-gain in the sub-material from the first to the third meeting has increased. This indicates that the students' critical thinking skills increased from the first meeting to the third meeting. The result of the student response questionnaire has obtained an average of 3 out of 4 with good criteria. This indicates that students express a good response to the use of worksheet.

The implementation of a large-scale experiment conducted in knowing the critical thinking skills obtained by the analysis of critical thinking skills test is 72 from a maximum score of 100 with a percentage of mastery of 61% with good criteria. This worksheet is effectively used in learning activities. The effectiveness can be realized because the applied worksheet is in scientifically based. Scientific approach based worksheet is worksheet which based on need analysis of the curriculum with the aim of developing students' critical thinking skills. This worksheet has a formula based on the scientific approach stages. The activities reflected in the worksheet follow the steps of scientific approach. Systematically, the correlation to be achieved through the use of worksheet is presented in table 2 below:

Table 2. The correlation between scientific approach stages and the indicator of critical thinking skills

Scientific Approach Stages	Sub – Critical Thinking Skills
Observing	1. Focusing on questioning 2. Analyzing arguments
Questioning	
Collecting information/experimenting	3. Considering credibility (criteria for sources)
	4. Observing and considering the result of an observation
	5. Making and considering induction
Associating	6. Making and considering score
	7. Defining and considering terms
	8. Identifying assumptions
	9. Determining an action
Communicating	10. Interacting with others

The research by Pusfarini (Pusfarini & Jalmo, 2016) supports a statement about the effectiveness of worksheet applied in learning activities. She found that effective worksheet were used in the application of problem-based learning with high effectiveness (N-gain = 0.68). In Wulandari's study (Wulandari, Sutawidjaja, & Susiswo, 2015) about students' worksheet with Problem Based Learning reach 84.41% percentage and the result of students' response questionnaire obtained 3.24 score which is valid, practical, and effective to improve students' understanding.

Furthermore, to know the correlation between critical thinking skills and students' IQ, researchers conducted a correlation test and regression. The whole test of this data analysis is using SPSS program. Below is table 2 which shows the correlation test results between the score of critical thinking skills and the students' IQ score.

Table 3. Correlation Analysis Score of Critical Thinking Skills (CTS) and IQ

		CTS	IQ Score
CTS	Pearson Correlation	1	,185
	Sig. (2-tailed)		,303
	N	33	33
IQ Score	Pearson Correlation	,185	1
	Sig. (2-tailed)	,303	
	N	33	33

The table 3 shows that the correlation between IQ and CTS (Critical Thinking Skills) scores has a positive correlation indicated by a value of 0.185. It means that the higher one's IQ score, the greater his CTS score is. The correlation value (0.185) <0.5. It means that one's IQ scores correlated very weakly with the CTS score. If it is statistically stated, then the hypothesis becomes:

H_0 is There is no correlation between the IQ score and the CTS score.

H_1 is There is a correlation between the IQ score and the CTS score.

If you want to test this hypothesis, it can be done in a two-sided test. The basis of the decision to conduct the two-sided test is based on the following odds:

If the odds > 0,05 (or 0,01), so H_0 is accepted

If the odds < 0,05 (or 0,01), so H_0 is rejected

The decision of this research is found in Sig. A 2-tailed statement which obtained the number of odds is 0.303, then there is no correlation between both variables from the number of students as much as 33 people. This can be indicated by the ** sign on the correlation number.

Furthermore, after obtaining correlation data, then the researcher looked for the data about its regression to know the cause-effect correlation between one variable to another one in this study. Below is table 4 that illustrates the degree of closeness of correlation between variables:

Table 4. Regression Analysis (Inter-variable correlation degree)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,185[a]	,03	,003	10,43419

a. Predictors: (Constant) IQ Score

Table 4 can be explained into several points, including:

a. The value of number R is 0.185 (a) shows that the correlation between IQ score and CTS score is very weak (because of the magnitude <0.5);
b. The value of R Square or commonly referred to Coefficient of Determination is 0.034. This means that 0.034 or 3.4% variation of the CTS score can not be explained by the variation. While the rest (100-3.4 = 96.3) or 96.3% explain the other causes;
c. Std Value. Error of the Estimate is 10.34319. It shows the level of accuracy of the regression prediction, with the explanation: the smaller the score the better the

prediction is. Based on the values in the table above, it shows that the regression prediction is not good;

To know the level of regression significance, it can be seen in table 5 below:

Table 5. Regression Analysis (Significance of Regression Degree)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	119,202	1	119,202	1,095	,303[b]
	Residual	3375,041	31	108,872		
	Total	3494,244	32			

b. Predictors: (Constant), IQ Score

Table 5 shows the significance level of the regression analysis. From the F-test test or known as ANOVA test, we get Fcount 1,095 with a significance level of 0.303. Due to this significance level is greater than 0.05, this regression analysis can not be used to predict students' CTS. In other words, the students' IQ score has no effect on students' critical thinking skills. Then, to know the regression coefficient, it can be seen from the table 6 below:

Table 6. Regression Analysis (Coefficient of Regression) of CTS

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	66,410	5,780		11,489	,000
	IQ Score	,161	,154	,185	1,064	,303

Table 6 shows the value of the regression coefficient. The value is derived from the regression equation as it follows: CTS = 66.410 + 0.161 IQ with a constant value of 66,410 which states that if the score of the IQ is large, then CTS scored 66,410. Qualitatively, it can be interpreted that the greater the IQ score, will get the greater the CTS score. But keep in mind that the three variables are ordinal scales, do not have the number "zero" as in the interval scale constraints. The value of the regression coefficient is 0.161. It shows that if the IQ score of the students increases +1 point, then the CTS will also increase in 0.161 points. The t-test seen in the table is used to test the extent of significance between constants with each independent variable. The hypothesis built in this study is as it follows: H_0 is the coefficient of regression is not significant between the constant with its variable. Meanwhile,

H_1 is the significant regression coefficient Decision making (based on odds) is as it follows:: If the value > 0.05 then H_0 is accepted. while the significance value <0,05, then H_0 is rejected, or H_1 accepted. Column Sig. shows that the two variables, ie constant = 0,000, Percent IQ = 0.303 has a significance value> 0.05. so H_0 is accepted or in other words the two variables do not significantly affect the students' CTS. The above case might be due to the data related to it.

The statements based on the results of correlation and regression analysis are supported by Russo (2004). He conducted a study of two groups of students with high and medium IQs, wanting to know the relationship between IQ with high students' thinking skill. The result is that IQ is only a measure or prediction of one's intelligence but can not measure high-level of students' skills. There is no indication that students with high IQ, have higher-order thinking skills greater than the students with average IQs. So, it can be concluded that IQ is not correlated with one's high-level skills. This is supported by previous studies indicating that IQ tests and high-order thinking can be separated (Richardson & Norgate, 2014; Stanovich & West, 2014; Webb, DelDonno, & Killgore, 2014). Many other researchers also point out that IQ is not the only predictor of achieving high-level thinking skills and can only be one method for identifying different thinkers (Butler, Pentoney, & Bong, 2017; Dumas, 2018; Tsai, Chang, & Lo , 2018).

4. Conclusion

Learning by using worksheet of rotational dynamics has a significant effect on students' high-order thinking skills, especially their critical thinking skills scores which are increasing. So this worksheet is very effective to be applied in the physics learning instruction, especially to improve critical thinking skills. In addition, other results of this study indicate that there is no correlation between IQ and critical thinking skills. It can be seen from the results of correlation analysis and regression. Hence, a student with a high IQ score does not necessarily predict that his critical thinking skills are also high. It is suggested for further research to see intelligence based on multiple intelligence. So more intelligence can be extracted.

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