The Different Ability of Free Body Diagram (FBD) Representation In Newton's Law Topic Based on Students' Thinking Style

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S. Linuwih, P. Asih* and Ellianawati

Physics Program, Faculty of Mathematics and Science Education UniversitasNegeri Semarang, Indonesia

*Corresponding author : pujiasihpj@gmail.com

Abstract. This study aims to determine the different ability of free body diagram (FBD) representation in Newton's Law based onstudents' thinking style. The subject of this research is the students of 10th grade from science class at state senior high school 1 of Prembun. The data analized is the results of cognitive test and students' thinking character questionnaire. The data were analyzed by using quantitative method. Based on the result, can be concluded that there is no difference between the ability of free body diagrams representating with a category sequential concrete, sequential abstract, random concrete and random abstract, which in the four categories of thinking styles included in the criteria need improvement.

1. Introduction

Physics as a process or scientific method includes ways of thinking, attitudes and steps of scientific activities to obtain scientific products. The development of reasoning ability in thinking inductively and deductively by using principles and concepts to explain various natural phenomena and solve problems is the goals of learning physics in the 2013 Curriculum [1]. Learners or students still have difficulties in understanding concepts and solving problems. When solving problems, they only use what is known to the problem to find equations to calculate numerical answers and solve problems without understanding the physics of the problem [2].

Each student has different ways and thought processes in solving physical problems. Several previous studies have revealed the ability of students to solve physics problems. Most students made mistakes in the problem solving process because they were unable to involve multi-representations properly [3]. The errors of students in solving physics problems because they could not describe the decomposition of all vectors that work on an object into its components, and errors in mathematical operations [4]. This shows that the ability of representation is important to help students in solving physics problems. Physics materials that are difficult to understand and mis-interpretations of representations such as work and energy, the dynamics of motion, fluid, etc.

One of the fundamental formulas in the dynamics of motion is Newton's law. However, students still have various difficulties in solving Newton's Law problems, including when determining the forces that interact with objects. The strategy used in solving Newton's law problems is by making interaction diagrams and free body diagrams [5]. FBDs can help students to analyze the forces acting on objects and solve Newton's Law problems [6]. In addition, free body diagrams can also help confront mathematical equations [7] Students can identify all the forces and where the force works by

separating objects from the environment by using it. If all forces acting on objects are correctly identified, students can solve physical problems precisely [8].

Gregorc grouped way of thinking into four groups which included, Concrete Sequential thinking style, Abstract Sequential, Random Concrete and Random Abstract [9]. People who are categorized into the "sequential" category tend to have a predominance of thinking using the left brain, whereas people who fall into the "random" category usually have a tendency to think with the right brain [10]. Students need to find their own thinking style so that they can learn more easily, quickly and effectively in understanding and solving problems [11]. Students's lack of attention about their learning styles can make them lose motivation for thiking, learning and achievement soon [12]. From the teacher's point of view, by knowing the students' thought processes, it can be traced where and the types of mistakes made by students. Learning with different methods according to the style of thinking can help activate the right dan left brain functions students'. Based on the description above, the author is interested to conduct research to find out wheter among the four thinking styles there are differences in the ability to represent free body diagram in Newton's law topic.

2. Methods

This research uses quantitative approach with the correlation method. The subjects of this study are the students of 10thgrade from science class at State Senior High School 1 Prembun. The samples are students of Class X MIPA 1. The samples of this study are taken using random sampling technique. This research is conducted through questionnaire and cognitive tests. The questionnaire instrument used in this study was adopted from a questionnaire about the characteristics of thinking styles created by John Parks Le Tellier to help students in knowing their thinking style. Students are given a thinking style questionnaire and then they are classified into four thinking styles namely Random Abstract, Random Concrete, Concrete Sequential, and Abstract Sequential.

The cognitive test is used to obtain data to represent free body diagram in the form of free body diagram picture. The instrument used for the written test was a question in the form of a description. The question consists of five items that required students to first make a free body diagram and then solve the next problem. The test is taken by all students of class X MIPA 1 individually in less than 60 minutes without opening notebooks and physics assignments or other reference sources. Furthermore, cognitive test results are classified using anfree body classification diagram designed by Rosrengrant . Rubric of free body diagram are presented in Table 1[13].

Table 1. The Classification of Free Body Diagram Rubric

Criteria		Description
0	No evidence of	Students do not draw the free body diagram
1	Inadequate	Students draw free body diagram but have not been able to determine the forces acting on objects correctly.
2	Need Improvement	Students have been able to draw a FBD and determine the forces acting on objects but have not been able to determine the size of the force vectors and the naming of forces acting on object.
3	Adequate	Students are able to draw a FBD correctly which includes the amount of force, the direction of the force and the size of the force vector acting on the object. In addition, the naming style is also correct.

In addition to classifying the results of students 'answers have the shape of free body diagrams, researchers also classify the results of students' answers in the form of calculations. Where students who do not answer the questions are given a score of 0, score of 1 for the wrong answer, score of 2 for an incomplete answer, and a correct answer is given a score of 3.

3. Result and Discussions

3.1. Identification of Students' Thinking Style

The distribution of students' thinking styles categories is shown in Table 2.

Table 2. Distribution of Students' Thinking Style Classifications

Thinking Style	Number of Students	Percentage (%)
Concrete Sequential	10	28
Abstract Sequential	9	25
Concrete Random	12	33
Random Abstract	5	14

Students with concrete sequential thinking styles hold to reguler information by connecting and easily remembering facts, information and formulas. For students with abstract sequential thinking styles, reality is abstract thinking, thinking in concepts and analyzing information well and easily finding key point. Students with random concrete thinking styles hold true to reality but also take a trial and error approach. While students with random abstract thinking styles holding on to feelings and emotions (influenting learning outcomes) and like an irreguler environment [14].

3.2. Students' Ability of RepresentingFree Body Diagram

The results of students' ability tests in drawing free body diagrams and completing calculation problems are shown in Table 3 with the criteria refers to Table 1.

Table 3. Grouping of the Results of Students' Answers based on the Free Body Diagram Scores and Calculations

Calculations	Free Body Diagram			
	0	**1**	**2**	**3**
0	2	0	0	0
1	3	32	48	5
2	0	2	30	8
3	0	3	39	8

The grouping of students' answers based on the calculation answers and the free body diagram scores can be seen in Figure 1 where the students classified as answering false are those who get a calculation score of 0, 1, and 2. Students who answer true are those who score 3.

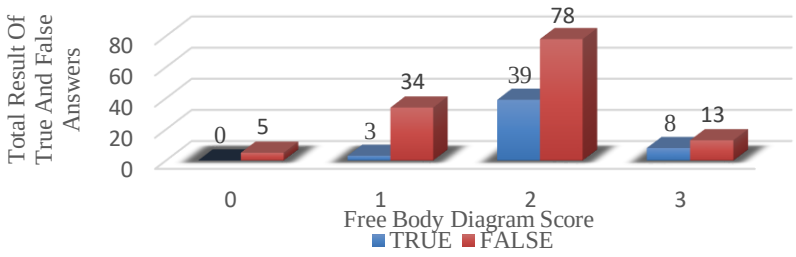

Figure 1. Group of Results Students' Answer Calculation based on the Free Body Diagram Score

Figure 1 shows that the results of the dominant students' answers are the answers of students who obtained a free body diagram score of 2 and a calculation score of 1. In accordance with the classification of the free body diagram of objects at Table 1 it can be seen that the students are in the category of Need Improvement. Students are able to draw a free body diagram and determine the forces acting on the object but have not been able to determine the length of the force vector and the naming of the force acting on each object. In addition, students create force vectors with incorrect base points.

The results of students' ability test of representation of free body diagram based on thinking styles are presented in Table 4.

Table 4. The Result of Ability Test of Representation of FBD based on Thinking Styles

Thinking Style	N	Min	Max	Average	Standard Deviation
Random Abstract	5	36.1	72.2	63.9	15.8
Concrete Random	12	41.7	75.0	53.7	9.3
Abstract Sequential	9	25.0	86.1	63.0	19.9
Concrete Sequential	10	33.3	88.9	57.2	16.8

3.3. Data Analysis of Prerequisite Test

Data analysis of prerequisite test is conducted to determine the statistics that is used in the hypothesis test. Normality test is carried out o check the normal distribution of the score data of of students' free body diagrams representation ability in each style of thinking. The normality test data used the Shapiro-Wilk test with the help of SPSS 22.0 software. The hypotheses used in this normality test are Ho for data distribution that is normal, while Ha for the data ditribution that is not normal.

Table 5. Results of the Normality Test Data Students' Ability of Representation by Thinking Style Type

	Thinking Style	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Score of the Ability of Free Body Diagram Representation	AR	.191	10	.200*	.945	10	.607
	CR	.186	9	.200*	.915	9	.352
	AS	.142	12	.200*	.931	12	.390
	CS	.370	5	.024	.737	5	.022

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

Table 5 shows that the result meets the requirements of parametric statistical analysis data on the ability to represent free body diagrams of students with concrete sequential thinking styles AR, CR and AS because of each has a Sig. amounted to 0.607, 0.352 and 0.390 which is greater than $\alpha = 0.05$ then Ho is accepted and Ha is rejected. This means that the test data of students' free diagrammatic representation abilities for AR, CR, and AS thinking styles come from normally distributed populations. As for data on the ability to represent objects free of objects with abstract random thinking styles derived from populations that are not normal because it has a value of sig. (0.022) < α (0.05). Therefore, it does not meet the requirements of parametric statistical analysis.

3.4. Hypothesis Test

The total score of each student is obtained according the results in the form of FBD score and calculations. The results of them are then correlated using the product moment correlation formula. From the calculation it turns out that r_(count) (0.7663) is greater than r_table (0.3298). Thus the coefficient of 0.7663 is significant and the correlation coefficient is strong referh to . So there is a relationship between the free diagram of objects and the results of calculations.

Hypothesis test with Kruskall-Wallis one-way analysis of variance is conducted to test the hypothesis of an independent sample when there is at least one group of data distribution that is not normal. In this study, the Kruskall-Wallis test was used with the help of SPSS 22.0 software to test the interaction of the results of the ability test of the student's free body diagram representation and the their thinking styles of CS, AS, RC, and RA. The hypothesis used in the Kruskall-Wallis test are if there is no significant difference in representing an object free diagram between the four thinking styles, Ho is accepted and Ha is rejected.

The analysis of the two average test differences is conducted using the Kruskall-Wallis test. The results of calculations using SPSS are presented in Table 6.

Table 6 Mean Rank Students' Thinking Style

Students' Thinking Style		N	Mean Rank
The ability of Free Body Diagram Representation	RA	5	23.60
	RC	12	14.54
	AS	9	22.11
	CS	10	17.45
	Total	36	

Based on Table 7, the mean rank values indicate the average rank of each thinking style. In the mean rank data, the average RA thinking style ranking is highest than among the four thinking style. Table 7 shows the results of the Kruskall-Wallis test the ability to test the free diagram representation based on students' thinking style.

Table 7 The Result of Kruskall-Wallis Test Students' Thinking Style toward the Ability of FBD Representation

	The Value of FBD Representation
Chi-Square	4.035
df	3
Asymp. Sig.	.258

a. Kruskall Wallis Test
b. Grouping Variable: Students' Thinking Style

Based on the calculations presented in Table 8, the value of sig is 0.258. This means that Ho is accepted and Ha is rejected because the significance value is more than α (0.05). This shows that the ability to represent objects free diagrams in the for thinking styles is not significantly different. It does not mean that these four characters do not have an influence on learning outcomes. This can be caused by several things. One of them is the test instrument for the free body diagram representation ability that is used should include test instruments for each style of thinking. This is in line with what was stated by Hudson that "sequential thinkers are those who are substantially better at intelligence tests than open-ended" open tests, whereas for random thinkers are the opposite "[15].

4. Conclusions

Generally, there is no difference in the ability to represent free body diagrams of class X students in SMA N 1 Prembun, which in the four categories of thinking styles included in the criteria need improvement.

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