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The Effectiveness of Inquiry Worksheets Based on Multiple Intelligences to Improve Students' Higher Order Thinking Skills

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Abstract:- The purpose of this study was to determine the effectiveness inquiry worksheets based on multiple intelligence to improve students' higher-order thinking skills on the topic of torque. One group pretest posttest design was used in this study with one sample t test and N-gain test are used for data analysis. The test results show significant differences between pretest and posttest score and also the N-gain category obtained on each indicator of higher order thinking skills, namely medium category for analyze and evaluate and also high category for create. Through the effect size test, this worksheet has also been shown to provide a moderate effect on analyzing indicators and a strong effect on evaluating and creating indicators.

Keyword:- *Inquiry Worksheets, Multiple Intelligences, Higher Order Thinking Skills.*

I. INTRODUCTION

Learning science especially physics requires teachers to be able to provide learning experiences as the laws and concepts of physics are obtained. Therefore physics learning should be learning that is students-centered and uses a scientific approach. The inquiry-based learning model is the most prominent learning model to be applied in science learning [1]. Where the learning not only approves scientific facts and theories, but understands how scientific knowledge is generated. The inquiry-based learning model is also a student-centered learning model. Ref. [2] revealed that inquiry-based learning as a student-centered approach had a positive influence on students' academic success, and could develop their scientific process skills, as well as their scientific attitude.

Physics learning with inquiry-based learning should be supported by teaching materials that can accommodate the learning, namely by using Student Worksheets. Ref. [3] research results show that students get a stronger understanding of physics concepts in the implementation of guided inquiry worksheets.

Inquiry-based learning as student-centered learning model, where students are physically involved and think actively during learning process. Similarly to the application of multiple intelligences in learning process. According to [4], we can improve education and develop learning by utilizing students' multiple intelligences. Several studies have been conducted, learning process that is conducted based on multiple intelligences for various topics, showing an increase in the effectiveness of such learning [5] [6] [7].

Physics learning with inquiry worksheet based on multiple intelligences as an update to this study is a development in physics learning. Blending the inquiry learning and multiple intelligences that have been proven effective in improving student learning outcomes can be a breakthrough to improve student learning outcomes, especially higher order thinking skills (HOTs). HOTs are a necessity in learning science. The research results of [8] shows that students who study with inquiry-based learning have higher HOTs scores.

Torque topic is one of the subjects in physics that is closely related to the application of vectors in three-dimensional fields, so learning this topic requires experimentation and investigation so that students more easily understand the topic. The relationship of each scale that affects the amount of torque will be easily understood if students are involved and interact directly with the conditions and environment in a framework that applies the torque concept. Learning with inquiry-based learning is appropriate for the torque topic.

The inquiry step used in the worksheets in this study was adapted from the research of [9] states, the stages of the inquiry-based learning begins with formulating the problem (initiation), developing hypotheses (selection), designing experiments (exploration), conducting experiments (formulation), make conclusions (collections), and communicate the results of experiments (presentations). Each of the stages of inquiry has been integrated with three types of multiple intelligences from the nine multiple intelligences proposed by [4] and [10]. The third multiple intelligences adjusted by observing the tendency of the way of students' learning in science class and torque topic character. All three are logical-mathematical, verbal-linguistic, and interpersonal intelligence.

Based on how each individual learns in terms of type of multiple intelligences adapted from [4] and [10], then the individual learning styles with proper logical-mathematical intelligence engage in learning by inquiry. Individuals with logical-mathematical intelligence learn by arranging work steps, analyzing patterns of relationships, and building concepts about science. This inquiry-based learning can also

accommodate the learning needs of individuals with verbal-linguistic and interpersonal intelligence. Verbal-linguistics tends to learn by reading, writing, talking, or listening. While interpersonal intelligence learns by discussing and linking scientific concepts with everyday events. So it is appropriate that the tendency for the way of learning the three intelligences be integrated into the stages of the inquiry-based learning.

The inquiry worksheets based on multiple intelligences used in this study was authenticated to improve students' HOTs. Every inquiry step used in each of these worksheet activities will refer to three HOTs indicators. The three indicators were adapted from Bloom's taxonomy which was revised by [11]. The detailed description of Bloom's taxonomic revision at the HOTs thinking level is shown in Table 1.

Thinking level	Category	Keywords
HOTS-Higher Order Thingking Skill	***Analyze*** Can students sort out the sections based on their differences and similarities?	Analyze, compare, contrast, differentiate, discriminate, separate, test, experiment, question.
	Evaluate Can students state good or bad about a particular phenomenon or object?	Giving argument, defending, stating, choosing, giving support, giving evaluation, evaluating
	Create Can students create an object or viewpoint?	Assemble, change, build, create, formulate, design, establish, formulate, write

Table 1:- Bloom Taxonomic Revision Description
(*Adated from [11]*)

II. METHOD

One group pretest posttest design [12] was used in this study, as described below:

01──X──*02*
01 = Pretest
X = Treatment (learning process)
02 = Posttest

The sample of this study was 34 students of second grade of senior high school in one experimental class without a comparison class.

One Sample t-test was used to see the significance of differences average score between pretest and posttest. Furthermore, the N-gain test is used to assess the effectiveness of inquiry worksheets based on multiple intelligences by calculating the magnitude of improvement in learning outcomes on aspects of students' HOTs. Calculation of N-gain using equation (1) follows: [13]

$$\langle g \rangle = \frac{\bar{X}_{post} - \bar{X}_{pre}}{100 - \bar{X}_{pre}} \quad (1)$$

Where:

$\langle g \rangle$ = N-gain score
$\bar{X}_{post}$ = posttest average score
$\bar{X}_{pre}$ = pretest average score

The N-gain categories follows the criteria in table 2 below:

N-gain score	Category
$(\langle g \rangle) \geq 0{,}7$	High
$0{,}7 > (\langle g \rangle) \geq 0{,}3$	Medium
$(\langle g \rangle) < 0{,}3$	Low

Table 2:- N-gain Categories
(*Adapted from[13]*)

The average scores of both pretest and posttest are grouped by HOTs category. There are four categories , which are less, enough, good, and very good. Because the pretest and posttest scores range from 0 – 100, the grouping of categories uses 25 score intervals. The categories of HOTs can be seen in the following Table 3:

Score	HOTs Category
0-25	Less
26-50	Enough
51 - 75	Good
76 - 100	Very good

Table 3:- HOTs Categories

The effect of learning using inquiry worksheets based on multiple intelligences to the improvement of students' HOTs will also be seen from the size of the effect size . The size of the effect size is calculated using equation (2) as follows: [14]

$$d = \frac{m_A - m_B}{\sigma} \quad (2)$$

Where:

d = index effect size for t-test
$m_A - m_B$ = average difference between pretest and posttest
σ = difference in standard deviations between pretest and posttest

Criteria effect size using Cohen's d values following the Table 4 below: [15]

Value effect size	Criteria
0 - 0.20	Weak effect
0.21 - 0.50	Modest effect
0.51 - 1.00	Moderate effect
> 1.00	Strong effect

Table 4:- Efeect Size Criteria
(*Adapted from[15]*)

III. RESULT AND DISCUSSION

The average score students' learning outcomes after treatment using inquiry worksheets based on multiple intelligences showed an increase. The average score both pretest and posttest can be seen in the following Fig. 1:

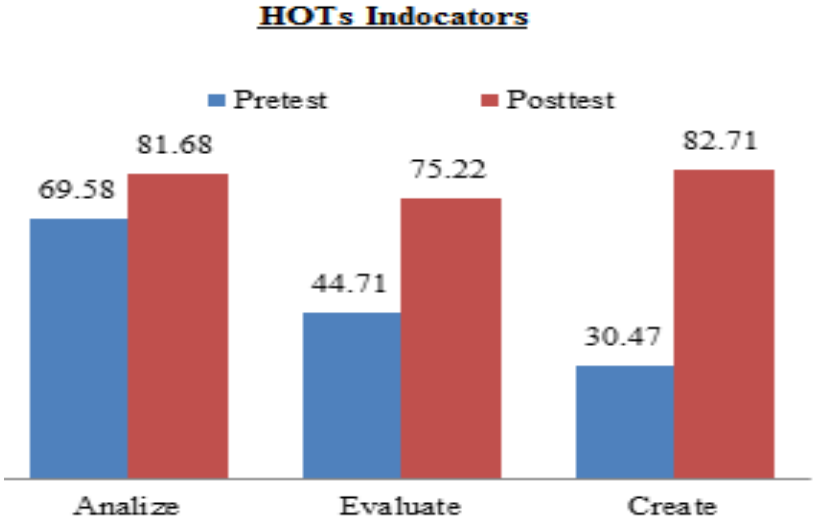

Fig 1:- Pretest and Posttest Average Score

Improved learning scores outcomes before and after learning process indicates an increase in students' HOTs. This can be seen in Table 5, there is a significant difference in average scores between the pretest and posttest. The results of One Sample t-test is obtained significance value of 0,000 (<0,05), meaning that there is a real difference between the pretest and posttest average score.

In Table 5 it also appears that each HOTs indicators gets an pretest average score into the good category to analyze and also enough category to evaluate and create. While posttest average score show an increase in HOTs category, which is very good for analyzing, good for evaluating, and very good for creating. This is supported by the results of the N-gain earned on every indicator, the N-gain categories are medium category for analyze and evaluate, whereas high category to create.

HOTs Indicators	Average score		Sig.(2-tailed)	N-gain	N-gain category
	Pretest	*Posttest*			
Analyze	69,58	81,68	0,000	0,40	Medium
Evaluate	44,71	75,22	0,000	0,55	Medium
Create	30,47	82,71	0,000	0,75	High

Table 5:- Achievement Results HOTs Indicators

The average pretest score in HOTs category is enough and good category, indicating that the learning carried out so far has not trained students' HOTs. However, after learning process is done by using inquiry worksheets based on multiple intelligences, there is an increase in the HOTs categories. This shows the strong influence of learning by using inquiry worksheets based on multiple intelligences. The effect size test results with Cohen's d equation show a moderate effect on analyzing and a strong effect on evaluating and creating. These results are shown in Table 6 below:

HOTs indicators	Mean Difference	Standard deviation of difference	Effect Size (Cohens'd)	Effect size category
Analyze	12,10	15,729	0,77	Moderate effect
Evaluate	30,51	16,141	1,89	Strong effect
Create	52,24	22,626	2,31	Strong effect

Table 6:- Effect Size Test Result

The stages of learning with inquiry worksheets based on multiple intelligences follows the steps of the inquiry-based learning model. First phase formulating the problem, before students formulate the problem students are invited to observe the phenomena related to the application of torque concept. Furthermore, with the instructions in the worksheets, students are directed to formulate problems based on the phenomenon that is about how the relationship of force and arm length to torque value.

The second phase developing hypotheses, with the instructions in the worksheets student directed to compose hypotheses based on the formulation of the problem that has been made previously. Furthermore, in the third phase of designing experiments, students are directed to be able to determine the tools and materials, as well as given an empty space in the worksheet to be able to arrange the experimental steps in hypothesis testing.

The fourth phase the hypothesis testing, students conduct experiments using tools and materials that have been determined to the hypothesis testing. Furthermore worksheet directs students to analyze the results of the experiment. Until this phase students have been trained to be able to analyze how the relationship between force magnitude and arm length to torque value. Students use their ability to analyze concepts, reasoning patterns of relationships between quantities, determine the steps of the experiment, communicate both verbally and in writing, and also discuss in the groups. This is a way of learning individuals with logical-mathematical, verbal-linguistic, and interpersonal intelligence. Up to this phase those three multiple intelligences were indeed observed to be dominant during learning process.

In this fourth phase, the worksheet also invites students to be able to evaluate the right tools to use based on the torque concept. This activity aims to improve the ability of students to evaluate and improve students' understanding of the application of the torque concept in everyday life. Logical-mathematical, verbal-linguistic, and interpersonal intelligence again appears dominant in this phase.

The fifth phase makes conclusions, worksheet directs students to make conclusions based on the results of hypotheses testing and data analysis about how each scale relates to the torque concept and formulates equations to calculate the torque value. This phase trains the ability of students to be able to create.

The sixth phase communicates the results of the experiment, groups of students are asked to be able to present the results of their group work in front of the class. Until this last phase, logical-mathematical, verbal-linguistic, and interpersonal intelligence still appear dominant during learning process. This is consistent with the character of learning physics, which involve the ability to reason, analyze, logic, arithmetic, cooperate and communicate in the students group orally and in writing.

The six phases of inquiry-based learning that used in inquiry worksheets based on multiple intelligences in this study have been able to increase students' HOTs. These results are similar to [16] which revealed that the stages of learning with inquiry-based learning stages that help students practice their HOTs where students will use logic, think creatively, and build their knowledge.

IV. CONSLUSION

Based on the results of research and discussion it can be concluded that the inquiry worksheets based on multiple intelligences is effective to improve students' HOTs on the topic of torque. The effectiveness of inquiry worksheets based on multiple intelligences provides a moderate effect on the ability to analyze and a strong effect on the ability to evaluate and create.

SUGGESTIONS

Based on the experience of applying multiple intelligences based learning, it is recommended that classifications of students' classes should be based on their multiple intelligences. This can facilitate the teacher in designing the appropriate learning approach and makes it easy for students to learn based on the type of their multiple intelligences.

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