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The Application of Students Worksheet based on PhET Simulation to Increase the concept understanding in Hooke's Law

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Abstract – This study aims to find out : 1) an overview of students ' conceptual understanding before being taught by using students worksheet based on PhET simulation , 2) to find out an overview of students ' conceptual understanding after being taught using students worksheet based on PhET simulation , 3) to find out the increasing of conceptual understanding before and after being taught using students worksheet based on PhET simulation. A pre-experimental study was carried out with one group pretest-posttest design. The subjects of this study were all of the students of class XI MIA 2 Madrasah Aliyah Lita, Bone Regency. The sampling technique used was purposive sampling. The instruments used is a test to measures understanding of the concepts. The results of the descriptive analysis show that the average scores of understanding concepts before using the students worksheet based on PhET simulation is 28.10, while the average value for understanding the concept of students after being taught using the students workseet based on PhET simulation is 75.71. Thus, it shows that there is an increasing of student concept understanding before and after applying the students worksheet based on PhET simulation, the t count obtained is 5.43 and the t table obtained is 2.08. There is a significant difference between the understanding of the physics concept of class XI MIA 2 Madrasah Aliyah Lita Bone regency before and after applying PhET-based worksheets simulation.

Keywords : Concept understanding ; PhET ; Hooke's Law

I. INTRODUCTION

Teachers as educators are required to design learning that leads students to meet the needs of the 21st century (Renata, 2021). In this case, physics learning activities cannot be separated from increasing student competence and skills (Inayah & Masruroh, 2021). Learners who have an understanding of concepts are able to make reliable conclusions, have broad insights, make wise decisions, produce quality products (Capriconia & Mufit, 2022). To support students in an effort to improve their understanding of a concept. The process of concept discovery involving basic skills through scientific experiments can be carried out and improved through practical activities in the laboratory (Nanda & Rajo, 2022).

Hooke's Law is one of the teaching materials for Class XI MA students. This material studies the concept of elasticity. To improve students' concept understanding, this material needs to be supported with practical activities (Sukarelawan et.al., 2022). Through practical activities, there are four skills that will indirectly reflect the characteristics of 21st century learning, namely Critical Thinking (critical thinking), Collaboration (ability to work well together), Communication (ability to communicate), and Creativity and Innovation (creativity and innovation) (Wahyudha, et al., 2021).

One alternative to overcome this problem is to apply learning innovation media in the form of using interactive media so that students can understand physics concepts as a whole (Ozkan et al., 2020; Niswaty & Arhas, 2019). The limitations of practical activities in the laboratory by students can be overcome by virtual practicum (Annanias et al., 2020). Virtual practicum that presents virtual practicum can be accessed using a computer or smartphone so that it can help smooth the learning process (Bahtiar & Azmar, 2022).

Students can use virtual laboratories if they are constrained by equipment or equipment in real practicum activities (Edi Saputra, 2021). Among the various types of virtual practicum applications, PhET (Physic Education and Technology Simulation) is one of the interactive media that can be utilised (Andriani et al, 2021). PhET Simulation has advantages, including: (1) it has an attractive animation display; (2) it is very easy to operate; (3) it is free to download; (4) it can adapt to laptop/PC specifications because it provides simulation package downloads, Java, and flash; (5) it can be used online or offline; and (6) it presents conceptual models of physics that are easy for students to understand (Khaeruddin & Bancong, 2022)

Some previous studies as reference material for this research, which are (1) Research conducted by Susilawati et. al,.

(2022) with the research title Concept understanding of students through core physics learning tools based on guided inquiry assisted by PhET virtual media. Students' understanding of concepts has increased the use of these devices in the high category. This means that students' understanding of concepts is effectively improved using an inquiry model with the help of PhET virtual media; (2) Research conducted by Eveline, et al (2019) with the title " The Effect of Scaffolding Approach Assisted by PhET Simulation on Students' Conceptual Understanding and Students' Learning Independence in Physics. In his findings, scaffolding approach with PhET simulation can be use to improve students' learning independence; (3) Research conducted by Haryadi & Pujiastuti (2020) with the research title " PhET simulation software-based learning to improve science process skills. PhET simulation software-based learning is interactive learning in physics learning and can improve students' science process skills; (4) Research conducted by Bahtiar et al., (2021) with the title Analysis of students' scientific literacy skill in terms of gender using science teaching materials discovery model assisted by PhET Simulation. This study aimed to analyze scientific literacy skills in terms of gender using discovery model science teaching materials assisted by PhET simulation.

Based on a variety of positive responses about the use of PhET Simulation and students

worksheet in the literature review above, the researchers are interested in carrying out similar research, but in a different context. The difference between previous research and the research we will do is in terms of its application. Where researchers plan to make students worksheet on material Hooke's Law based on PhET Simulation and then applied directly to the learning of Hooke's Law material for Class XI MA students.

Based on the results of an interview with one of the students on behalf of Ibnu Muzammil who is the head of class XI MIA 2 Madrasah Aliyah Lita Bone regency, he said that laboratory activities had never been carried out during the pandemic, even though before the pandemic there were still several experiments such as Hooke's law and gas kinetic theory (Boyle's law, Gay law). Lussac, Charles' law, and Boyle-Gay Lussac law) that could not be carried out. In line with that, based on the results of an interview with a physics teacher at Madrasah Aliyah Lita Bone regency, it is known that students' mastery of concepts is still low, because there are still many students' test results that do not meet the Minimum Completion Criteria value, which is only 60. According to the physics teacher at Madrasah Aliyah Lita Bone regency, the low minimum completion criteria value may be influenced by the lack of student learning experience through practicum. Based on the results of these interviews, to improve the understanding of the concept of students in

class XI MIA 2 at Madrasah Aliyah Lita, Bone regency, then through learning media with real laboratories can improve students' skills in using existing laboratory equipment to prove the truth of an experiment or trial. However, the tools and media in the laboratory are often damaged or broken during the experiment, causing a shortage of equipment in the laboratory. This causes practicum activities to not run smoothly if laboratory equipment is inadequate.

Based on the description above, this research has not been so thorough so that researchers are interested in conducting research entitled "Implementation of LKS Based on PhET Simulation of Hooke's Law Material to Improve Students' Concept Understanding of Class XI MIA 2 Madrasah Aliyah Lita Bone regency. The research problem that arise from this background study; (1) How is the understanding of physics concepts of students in class XI MIA 2 Madrasah Aliyah Lita Kab. Bone before being taught using LKPD based on PhET simulation? (2) How is the understanding of physics concepts of students in class XI MIA 2 Madrasah Aliyah Lita Kab. Bone after being taught using LKPD based on PhET simulation? (3) Is there any significant difference between the understanding of the physics concept of class XI MIA 2 Madrasah Aliyah Lita Bone regency before and after applying PhET-based worksheets simulation?

II. METHODS

This study was conducted at Madrasah Aliyah Lita Bone regenvcy in the 2021/2022 school year from 25 October to 25 November 2021. The type of research used is Pre-experiment (Sugiyono, 2019). Then the design used is One Group Pretest Posttest Design. This design can be described as follows (O'leary, 2021):

O_1	X	O_2

Figure 1. *One Group Pretest Posttest Design*

Description:

O_1 : P at the beginning of the activity before the treatment is given, subjected to all subjects (O) pretest to measure students' understanding of concepts

X : The provision of treatment (X) to the research subjects, namely the provision of Hooke's law material to determine the spring constant through virtual lab simulation using PhET simulation.

O_2 : After the treatment is complete, a posttest is conducted on the research subject through a concept understanding test.

The research subjects in this study were students of class XI MIA 2 Madrasah aliyah Lita Bone, totalling 21 people.

The sample selection technique used in this study was purposive sampling. The researcher's consideration in choosing MIA 2 is due to the skills of students in this class who are qualified in terms of computer mastery

based on the advice of the physics teacher at Madrasah Aliyah Lita Bone regency.

The data analysis techniques used in this study are descriptive statistical analysis and inferential statistical analysis.

a. Descriptive Statistical Analysis
   1) Average (Mean)
   2) Standard Deviation
   3) Variance
   4) Concept Understanding Categorization

The following categorization is used to determine the level of understanding of the concept in students which refers to the guidelines of the Ministry of Education (2008).

Table 1. Categories of Understanding of Student Concepts

No.	intervals	Category
1	80-100	Very high
2	70-79	High
3	50-69	Low
4	≤ 49	Very low

b. Inferential Statistics
 1) Normality Test
Normality test in this study is using the lilifoers method .

 2) Homogeneity Test

In this study, homogeneity testing was carried out using the F-test .

3) Hypothesis testing

After the prerequisite test is carried out and it is proven that the processed data is normally distributed and homogeneous, then it is continued with testing the proposed hypothesis whether it can be accepted or rejected. Hypothesis testing in this study used a parametric 2-sample paired-sample T-test at a significant level of $\alpha = 0.05$ (Cohen et.al, 2014).

$$H_0 : \mu_1 = \mu_2$$
$$H_1 : \mu_1 \neq \mu_2$$

Description :

H_0 : There is no difference understanding concept to the participants educate before and after taught with using students worksheet based PhET simulation.

H_1 : There is difference understanding concept to the participants educate before and after taught with using students worksheet based PhET simulation.

III.   RESULTS AND DISCUSSION

1. Research result

### a. Descriptive Analysis

1)   Descriptive Analysis *(Pretest)*

Based on the test results of class XI MIA 2 Madrasah Aliyah Lita Bone, before applying understanding using recreational PhET-based student worksheets, information was obtained from the results of the spelling test which is expected to provide an overview of the value of student understanding of the ideas obtained, namely the highest score, the smallest score, the normal score (mean), standard deviation

and change and order of student understanding applied. The consequences of expressive investigation are as follows:

Based on table 2, the distribution of Hooke's law concept understanding scores of students in class XI MIA 2 Madrasah Aliyah Lita Bone in several categories, namely 5 students in the low category with a percentage of 23.8% and 16 students in the very low category with a percentage of 76.2%. From these data it can be seen that the level of understanding of the concept of students is still in the low or even very low category.

Table 2. Data from Pretest Analysis Results (Before applying PhET -Based Worksheets simulation)

Descriptive statistics	*Posttest*
Number of Samples	21
Maximum	50.00
minimum	10.00
Average	28.10
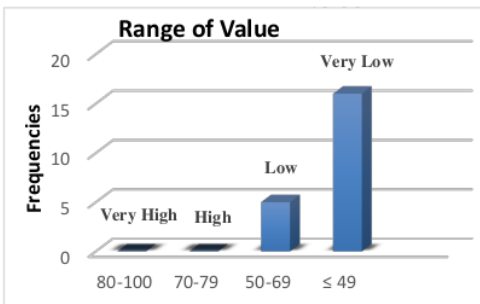
Figure 2. Histogram of pre value test

Based on the histogram in Figure 2, it can be concluded that most of the students' concept understanding scores are in the ≤49 score range, which is very low categorisation as many as 16 students, while the other 5 students are in the low category.

2) Descriptive Analysis *(Posttest)*

Based on the results of the concept understanding test of students in class XI MIA 2 Madrasah Aliyah Lita Bone, after implementing learning by using PhET simulation student worksheets, the data obtained from the results of descriptive analysis which aims to provide an overview of the students' concept understanding scores obtained, which includes the highest score, lowest score, average score (mean), standard deviation and variance and categorisation of students' concept understanding. The results of the descriptive analysis are as follows:

Table 3. Data from Posttest Analysis Results (After applying PhET -Based Worksheets simulation)

Descriptive statistics	*Posttest*
Number of Samples	21
Maximum	100.00
minimum	50.00
Average	75.71
range	40.00
Standard Deviation	16.00
Variance	255.7145

Based on table 3, the score distribution of Hooke's law concept understanding of students in class XI MIA 2 Madrasah Aliyah Lita Bone in several categories, including 10 students in the very high category with a percentage of 47.7% and 4 students in the high category with a percentage of 19% and 7 students in the low category with a percentage of 33.3%. The data in table 3 categorisation of understanding the concept of Hooke's law can be depicted in the form of a histogram of understanding the concept of Hooke's law of students in the pretest in Figure 3.
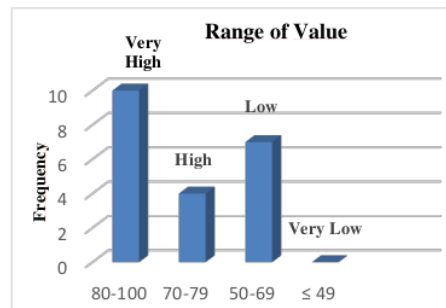
Figure 3 . Histogram Posttest scores

Based on the graph in Figure 3, it can be clearly seen that most students' concept understanding is in the range of 80-100, which means 10 students categorised as very high, 4 students categorised as high, and 7 students categorised as low.

b. Inferential Analysis

1) Normality Test

Normality test was analyzed using MS.Excel and the following results were obtained.

Table 4. Normality test of *pretest* data students taught using PhET simulation

lcount	**0.0594**
ltable	0.193
Lcount < Ltable = normal	

Based on table 4. it can be seen that in the experimental class 1 has a Dcount of 0.0594, which means it is smaller than the Dtable of 0.193. This shows that the data is normally distributed.

Table 5. Normality test of posttest data of students taught using PhET simulation

lcount	**0.065**

ltable	0.193
Lcount < Ltable = normal	

Based on table 5. it can be seen that the experimental class 1 has a Dcount of 0.132, which means it is smaller than the Dtable of 0.229. This shows that the data is normally distributed

2) Homogeneity Test

Based on data processing with Ms.Excel , the following results are obtained:

Table 6. Homogeneity Test

Variable	F_{Count}	F_{Table}
understanding Draft	1.34	2,12

Based on the table above, it can be seen that the concept understanding sample variant is homogeneous. This is because F Count < F Table where F count obtained is 1.34 while F Tabel is 2.12.

3) Hypothesis testing

After carrying out the normality test and data homogeneity test, it turned out that the data were normally distributed and the data were homogeneous. Therefore, in testing the hypothesis, the researcher used a parametric test with the t-test formula for two independent samples analyzed using MS. Excel.

Table 7. Hypothesis Testing

CONCEPT UNDERSTANDING	T_{Count}	T_{table}
	5.43	2.08

Based on the table above, it shows that t count> t table. The tcount value obtained is 5.43 which is not in the H0 region, so H0 is rejected and H1 is accepted, meaning that there is a statistically significant difference in class XI MIA 2 Madrasah Aliyah Lita Bone students before and after applying the PhET-based students worksheet on Hooke's law simulation material.

Based on the results of hypothesis testing using the t-test, the t-count value = 5.43 is obtained, while the t-table value = 2.08. Since the value of $t_{count}> t_{table}$, it can be concluded that there is a significant difference in class XI MIA 2 Madrasah Aliyah Lita Bone before and after the application of students worksheet based on PhET simulation material Hooke's law. Because the value of $t_{count}> t_{table}$ then H_0 is rejected and H_1 is accepted.

2. **Discussion**

a. *An overview of students' understanding of concepts before implementing PhET -based worksheets Simulation*

The concept understanding of students (XI MIA 2) before being taught using students worksheet based on PhET Simulation has been illustrated in the descriptive analysis described in the previous point (research results).

The average obtained from the descriptive analysis can be a point of reference to identify the concept understanding of students in class XI MIA 2 Madrasah Aliyah Lita Bone regency. Data analysis of the results of the concept understanding test before applying the PhET-based students worksheet simulation is on average 28.10 with a concept understanding

category of 5 students in the low category with a percentage of 23.8%, 16 students in the very low category with a percentage of 76.2%.

b. *An overview of students' understanding of concepts after implementing PhET -based worksheets Simulation*

Some topics in physics are not taught using practical methods, and the high price of laboratory equipment causes the availability of equipment in the laboratory to be limited, thus hindering the practicum.

PhET simulations provide animations of physics that are abstract or cannot be seen with the human eye, such as: atoms, electrons, photons, and magnetic fields. An interaction is done in the form of pressing buttons, shifting objects or entering data. Then at that moment the results of the interaction will be immediately visible. For quantitative exploration, this PhET simulation has measuring instruments in it such as a ruler, stopwatch, voltmeter, and thermometer. Students just need to use it to measure a quantity.

Students learn using PhET Simulation can make students feel comfortable while learning and not get bored quickly and more fun. As a result students' learning outcomes can increase.

Based on the results of the analysis above, the average student has a concept understanding score of 75.71 so that the

description of the test results of students' concept understanding after the application of PhET-based students worksheet simulation in physics learning in Class XI MIA 2 Madrasah Aliyah Lita Bone regency improved with categorisation, 10 students are in the category of very high with a percentage of 47.7%, 4 students are in the category of high with a percentage of 19% and 7 students are in the category of low with a percentage of 33.3%. This shows that the average score obtained between the pretest and posttest results has a significant difference, this can be seen from the categorisation results of the pretest and posttest concept understanding test results. Therefore, it can be concluded that the concept understanding of students of class XI MIA 2 Madrasah Aliyah Lita Bone regency has increased. Thus, this results support some previous studies (Inayah & Masrurah, 2021; Eveline, et. al, 2019). PhET simulation is one of the learning system applications that can help students enhance their understanding concepts (Bahtiar et al, 2022).

c. *Differences in Students' Understanding of Concepts before and after applying PhET - based worksheets Simulation*

From the explanation above, we can clearly understand that the application of PhET-based workseet simulation to students in class XI MIA 2 Madrasah Aliyah Lita Bone regency before and after has differences, this can be reflected in the average value before and after being provided with treatment, which is before

being given treatment has an average of 28.10 and after being given treatment it increases to 75.71, which shows that the results of the concept understanding test of students in class XI MIA 2 Madrasah Aliyah Lita Bone regency have increased significantly.

Based on the results of hypothesis testing, the obtained results are tcount ≥ ttable both based on the manual T test and based on the T test using SPSS, where the tcount value obtained manually is 5.435 and the ttable value is 2.086. based on these results, it can be concluded that H_0 is rejected and H_1 is accepted, so that overall there is a significant difference between before and after implementing the PhET simulation-based worksheet in class XI MIA 2 Madrasah Aliyah Lita Bone regency.

According to the Physics Minimum Completeness Criteria applied by XI MIA 2 Madrasah Aliyah Lita Bone Regency, overall the results of the concept understanding test of XI MIA 2 class students after applying the PhET-based worksheet are far more who have reach the minimum completion criteria than before applying the PhET-based worksheet the standard of the minimum completion criteria in physics subject applied at school XI MIA 2 Madrasah Aliyah Lita Bone regency is 70.00.

There is a significant difference between the test results of students' concept understanding before and after applying the PhET-based worksheet In addition, the

treatment given before the second test was also a lesson that required students to be actively involved during the learning process.

Based on the researcher's observation, before applying the PhET Simulation-based worksheet, the delivery of learning materials was delivered through lecturing method, question and answer, completing homework and not doing practicum. This causes learning activities to be teacher-centred, causing students to be passive in participating in learning. Students tend to memorise every learning material they receive without understanding and studying it further. This can lead to a lack of understanding of student concepts. Meanwhile, after applying the PhET-based worksheet simulation, students' concept understanding has been improved compared to before. This is due to the fact that students can receive and understand Hooke's law and elasticity material easily so that it affects their concept understanding.

Based on the exposure of some students, when learning by using PhET-based worksheets in simulation they are more likely to quickly understand and understand learning, they also more often ask questions related to Hooke's law than when using direct learning models. They feel that learning by using PhET Simulation-based worksheets is not that boring because students are more active in group learning.

The results of this study are in line with the results of research conducted by Toto et al., (2021) with the research title Improving Teachers' understanding and readiness in implementing STEM through science learning simulation. The creativity of the collaborative learning model with PhET simulation has a significant effect on problem solving skills.

Other studies that are relevant to this research are research conducted by Budiarti, et al (2020) with the title " Analysis of Students' Scientific Problem Solving Skills in Learning Using PhET Simulation in 3T Region. PhET Simulation is a tool or media that can be used by teachers and can improve students' exploration skills and make students more interested in the subject matter.

Based on the explanation above, it can be concluded that students' concept understanding has increased after applying the PhET Simulation-based Student Workshee. Thus learning by using PhET Simulation-based worksheets has been statistically proven to be able to answer the problems in this study, so that the hypothesis (H_0) is rejected and the hypothesis (H_1) is accepted, where there are differences in students' understanding of physics concepts before and after being taught using PhET Simulation-based worksheets in class XI MIA 2 Madrasah Aliyah Lita, Bone Regency.

The difference in the results of the pretest and posttest concept understanding tests of students in class XI MIA 2 Madrasah Aliyah Lita Kab. Bone. It is caused by several things, including the difference in the treatment given in the pretest and posttest, where during the learning before the pretest still uses a direct learning model, while in the post-test has been applied based on worksheet PhET simulation. Furthermore, during the pretest, students who were active in the learning process were only a few students, while during the posttest most students were actively involved in the learning process, which led to an increase in their concept understanding test results.

IV. CONCLUSION

Based on the result and discussion above, the understanding of the physics concept of class XI MIA 2 Madrasah Aliyah Lita Bone Regency before implementing PhET -based worksheets the average simulation is still in the very low category with a total of 16 students with a percentage of students 76.2%, in the low category with a total of 5 students with a percentage of 23.8% where no one has yet achieved the score of minimum completion criteria. Understanding of physics concepts of students in class XI MIA 2 Madrasah Aliyah Lita, Bone Regency after applying the PhET-based worksheet the average simulation is in the very high category with a total of 10 students with a percentage of 47.7% students, high category with a total of 4 people with a percentage of 19%, low category with a total of 7 people with a percentage of 33.3% who reached the minimum completion criteria was

66.7% or 14 students. There is a significant difference between the understanding of the physics concept of class XI MIA 2 Madrasah Aliyah Lita Bone regency before and after applying PhET-based worksheets simulation with the highest category in the pretest results is in the low category, where no students reach the minimum completion criteria, while in the posttest results the highest category is in the very high category, with a total of 14 students who have scores reaching the minimum completion criteria.

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