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The Application of Student Worksheets 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) the overview of students ' concept understanding before being taught by using student worksheets based on PhET simulation, 2) the overview of students' conceptual understanding after being taught using student worksheets based on PhET simulation, 3) the increase of conceptual understanding before and after being taught using students' worksheet based on PhET simulation. This 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 was a test to measure understanding of the concepts learned. The results of the descriptive analysis show that the average scores of understanding concepts before using the student worksheet based on PhET simulation is 28.10, while the average value after being taught using the students worksheet based on PhET simulation is 75.71. It indicates that there is an improvement in students' concept understanding before and after using the student worksheet based on PhET simulation. Meanwhile, the t-count obtained is 5.43 and the t-table obtained is 2.08. Thus, 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; hooke's law; phet

I. INTRODUCTION

Teachers as educators are required to design learning that leads students to meet the needs of the 21st century (Halubova, 2021). In this case, physics learning activities cannot be separated from increasing students' 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 (Safarati & Lubis, 2022; Sudirman & Amaliyah, 2022).

Hooke's Law is one of the teaching materials for Class XI MA students. This

material explains 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) (Setiyoaji 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 & Topsakal, 2020; Niswaty & Arhas, 2019). The limitations of practical activities in the laboratory by students can be overcome by virtual practicum (Yunzal & Casinillo, 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; Sudirman et al., 2021).

Students can use virtual laboratories if they are constrained by equipment in real practicum activities (Saputra et al., 2021). Among the various types of virtual practicum applications, PhET (Physic Education and Technology Simulation) is one of the interactive media that can be utilized (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; Sudirman & Kennedy, 2022).

There were some previous studies as reference material for this research. They are (1) Susilawati et al. (2022) revealed that 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) Eveline et al. (2019) found that scaffolding approach with PhET simulation can be used to improve students' learning independence; (3) Haryadi & Pujiastuti, (2020) also concluded that PhET simulation software-based learning is interactive learning in physics learning and can improve students' science process skills; (4) Bahtiar et al. (2022) 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 student 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 our research is in terms of its application, where researchers made student worksheets on

Hooke's Law material based on PhET Simulation and then applied directly to the learning of Hooke's Law material for Class XI MA students.

From the 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, it was known that laboratory activities were not maximally conducted. 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 pandemic, the schools had never been carried out any of laboratory activities. In line with that, the interview with a physics teacher at Madrasah Aliyah Lita Bone regency revealed 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, learning media and existing laboratory equipment can be used. 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 inadequate laboratory facilities may cause practicum activities to not run smoothly.

Based on the description above, this research has not been so thorough so that researchers are interested in conducting research regarding the Implementation of student worksheets based on PhET Simulation of Hooke's Law Material to Improve Concept Understanding of Students' Class XI MIA 2 Madrasah Aliyah Lita Bone regency. The research problem in this study are; (1) How is the physics concept understanding of students in class XI MIA 2 Madrasah Aliyah Lita Kab. Bone before being taught using student worksheets based on PhET simulation? (2) How is the physics concept understanding of students in class XI MIA 2 Madrasah Aliyah Lita Kab. Bone after being taught using student worksheets 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 simulation-based worksheets?

II. METHODS

This study was conducted at Madrasah Aliyah Lita Bone regency in the 2021/2022 academic year, starting 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, 2004):
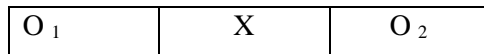
O$_1$	X	O$_2$

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 post-test is conducted on the research subject through a concept understanding test.

The research subjects in this study were 21 students of class XI MIA 2 Madrasah aliyah Lita Bone. 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 recommendation of the physics teacher at Madrasah Aliyah Lita Bone regency.

The data analysis techniques used in this study were 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 (Kemdikbud, 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 was conducted by 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 was carried out and it was proven that the processed data was normally distributed and homogeneous, we tested 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 $\alpha = 0.05$.

$$H_0 : \mu1 = \mu2$$
$$H_1 : \mu1 \neq \mu2$$

Description:

H$_0$: There is no difference in students' concept understanding before and after taught by using student worksheet based on PhET simulation.

H$_1$: There is a difference in students' concept understanding before and after taught by using student worksheet based on PhET simulation.

III. RESULTS AND DISCUSSION

A. Research Result

a. Descriptive Analysis

1) Descriptive Analysis *(Pretest)*

Based on the test results of class XI MIA 2 Madrasah Aliyah Lita Bone, before using PhET simulation-based student worksheets, the data obtained were the highest score, the smallest score, the normal score (mean), standard deviation and change and order of students' understanding applied. The consequences of expressive investigation are as follows:

Table 2. Results of Pretest Score Analysis (Before applying PhET simulation-Based Worksheets)

Descriptive statistics	*Pretest*
Number of Samples	21
Maximum	50.00
minimum	10.00
Average	28.10
range	40.00
Standard Deviation	14.01
Variance	196.19

Based on Table 2 above, it can be explained that the maximum value of concept understanding obtained by students for the experimental class before being given treatment (pretest) is 50, while the minimum value is 10, with a score range of 40, the average or mean is obtained from the overall value divided by the number of frequencies available. The average value obtained is 28.09, besides that it can also be seen the value of standard deviation and variance, standard deviation is a measure that describes the variability of the average value, where a value of 14.01 is obtained, while variance is a measure of the diversity of the data obtained, in the table above it can be seen that the variance obtained is 196.192. Based on the data obtained and the results of descriptive analysis, the concept understanding of students in class XI MIA 2 Madrasah Aliyah Lita Bone Regency is categorized with the results shown in the following table 3:

Tabel 3. The Categorization of Student Concept Understanding before the treatment

No	Interval	Frequency	Percentage	Category
1	80-100	0	0	Very High
2	70-79	0	0	High
3	50-69	5	23,8%	Low
4	≤ 49	16	76,2%	Very Low
	Total	21	100%	

Based on Table 3, the score of Hooke's law concept understanding of students in class XI MIA 2 Madrasah Aliyah Lita Bone were classified into 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.
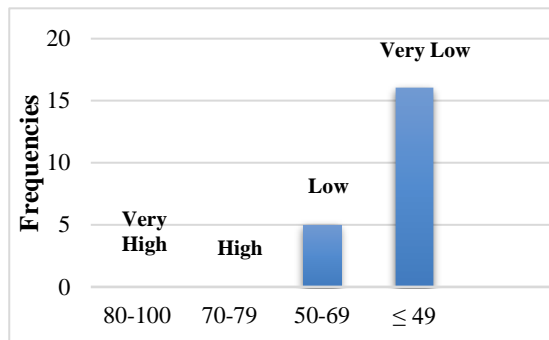
Figure 2. Histogram of Pretest Score

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 categorization as many as 16 students, while the other 5 students are in the low category.

2) Descriptive Analysis *(Post-test)*

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 categorization of students' concept understanding. The results of the descriptive analysis are as follows:

Table 4. Results of Post-test Score Analysis (After applying PhET Simulation-Based Worksheets)

| Descriptive statistics	*Pretest*
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 4 above, it can be explained that the maximum value is the highest physics concept understanding value obtained by students for the experimental class after being given treatment (post-test) is 100, while the minimum value is the lowest value obtained, namely 50, with a score range of 40, the average or mean is obtained from the overall value divided by the number of frequencies available. The average value obtained is 75.71, besides that it can also be seen the value of standard deviation and variance, standard deviation is a measure that describes the variability of the average value, where a value of 16.00 is obtained, while variance is a measure of the diversity of the data obtained, in the table above it can be seen that the variance obtained is 255.7145.

Based on the data obtained and the results of descriptive analysis, the concept understanding of students in class XI MIA 2 Madrasah Aliyah Lita Bone is categorized with the results shown in table 5 below:

Tabel 5. The Categorization of Student Concept Understanding after the Treatment

No	Interval	Frequency	Percentage	Category
1	80-100	10	47.7%	Very High
2	70-79	4	19%	High
3	50-69	7	33.3%	Low
4	≤ 49	0	0	Very Low
Jumlah		21	100%	

Based on table 5, 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 categorization of understanding the concept of Hooke's law can be depicted in the form of a histogram of students' understanding in the Hooke's law concept in the pretest in Figure 3 below.
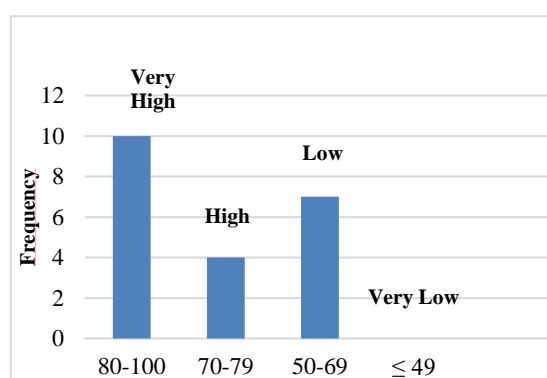
Figure 3 . Histogram Post-test scores

Based on the graph in Figure 3, it can be clearly seen that most students' concept understanding score is in the range of 80-100 or in the category of very high, 4 students' scores in high category, and 7 students' scores in low category.

b. Inferential Analysis

1) Normality Test

Normality test was analyzed using MS.Excel. Normality tests were conducted twice, for pretest and post-test. The following are the results obtained:

Table 6. Normality Test Of The Pretest Data

lcount	0.0594
ltable	0.193
Lcount < Ltable = normal	

Based on Table 6, 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 7. Normality Test Of The Post-Test Data

lcount	0.065
ltable	0.193
Lcount < Ltable = normal	

Based on Table 7, 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 8. 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 can be known 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 9. Hypothesis Testing

	T_{Count}	T_{table}
Concept Understanding	5.43	2.08

The table above 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 students' concept understanding 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 students' concept understanding 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.

B. Discussion

a. *The 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. *The 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.

Learning using PhET Simulation can make students feel comfortable, not 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 where 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 post-test results has a significant difference, this can be seen from the categorization results of the pretest and post-test 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

& Masruroh, 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 simulation-based worksheets, 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. (2021) with the title "Analysis of Students' Scientific Problem Solving Skills in Learning Using PhET Simulation in 3T Region. They found that 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 Worksheet. 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 post-test 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 post-test, 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 post-test most students were actively involved in the learning process, which led to an increase in their concept understanding test results.

IV. CONCLUSION AND SUGGESTION

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 simulation-based worksheets the average score 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 simulation-based worksheets with the highest category in the pretest results is in the low category, where no students reach the minimum completion criteria, while in the post-test 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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