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# The effect of project-based distance learning on mastery of work and energy concepts

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**Abstract.** This study aims to determine the effect of the project-based distance learning model on students' mastery of concepts on work and energy material. This research method is a mixed method with the Embedded Experimental Model design. Quantitative data came from working on the pre-test and post-test of mastery of the concept of 34 students, with the results of qualitative data through interviews and qualitative analysis. The results showed that the project-based distance learning model had a significant effect (d-effect size = 2.33) ($\alpha$=0.000) on students' mastery of concepts, and the magnitude of the increase in concept mastery used N-gain 0.766. Qualitative analysis used crosstabulation and the results of student interviews, which stated that students experienced an increase in mastery of concepts after being given treatment. The findings of the researchers proved that there was student creativity which was shown in high categories in each indicator of project outcome assessment based on aspects of fluency (85.2%), flexibility (75%), originality (80.1%), and elaboration (75.7%).

**Keywords:** creativity, concept mastery, distance learning, project-based learning

## I. Introduction

Physics subject is a branch of Natural Sciences that is used as a building or series of concepts and conceptual schemes that are interrelated as a result of experiments and observations. Students must master the physics material and concepts to participate in the high school physics learning process. They must also improve their analytical, critical thinking, and creative problem-solving skills [1], [2]. But, based on previous research, students need help mastering physics concepts [3]. One of the physics materials that makes it difficult for students to master the concept is work and energy. It is not easy to convey the abstract concepts of physics in terms of work and energy in verbal form.

Research shows that students struggle with calculations when solving problems and have difficulty determining formulas. Some students experience errors in solving problems due to a lack of mastery of concepts in work and energy material [4]. This is supported by research that proves that students have difficulty working on physics questions on work and energy materials [5]. Therefore, it is very important to apply a very effective and efficient learning model based on the situation and conditions during this pandemic which can support the learning process to improve the quality of education.

During the Covid-19 pandemic, the government issued an education policy during an emergency regarding guidelines for conducting learning from home, such as implementing distance learning [6]. Distance learning is a way of learning online or via the internet [7]. The existence of distance learning is an education system structured in distance teaching, where teaching and learning activities are carried out in different places [8]. Distance learning is also called a variation of education that links aspects of technology and information in the teaching and learning process. The existence of distance learning requires educators to master distance.

learning, which in the learning process pivots on using digital technology [9], [10]. The learning process carried out by educators in class uses several learning media, such as the Zoom application, Google Classroom, Google Meeting, Whats App Group, and so on. The Google Classroom application is used as a learning and teaching tool by providing material in the form of text and video. The evaluation of distance learning using Google Forms is very useful for realizing the effectiveness of the learning process during the social distancing period [11].

The distance learning model requires students to study independently at home without a time limit and place of study. This makes students work harder to understand learning material remotely than studying in the classroom with a face-to-face learning model with educators [12]. In previous research, it was stated that there was an ineffectiveness of using Google Classroom in physics learning because the material presented could not be understood by students just by reading, but students still needed educators directly in the physics learning process [13]. Therefore, physics learning through virtual classes such as the Zoom and Google Meet applications is necessary to support distance learning.

Distance learning during the Covid-19 pandemic on Work and Energy can be applied [14]. However, in that study, it was found that 96.4% of students had difficulty mastering material and questions related to statements, as well as limited data quota and slow internet networks. The impact of this research is that students' mastery of work and energy material concepts still needs to improve. This is evidenced by students' cognitive tests, which prove the average value of respondents < 60, which means they do not meet graduation standards. Research shows that virtual experiments conducted during distance learning can help students' practicum activities, and most students have mastery of high-category concepts after learning [15]. In fact, it is known that virtual practicum in distance learning can only be applied to some physics materials, so certain materials require more guidance from the teacher. This research still found a need for mastery of students' concepts, as seen from several indicators such as classification, comparison, and conclusion.

Distance learning and practicum can improve cognitive and psychomotor aspects [16]. However, the weakness of this study is that students have difficulty learning independently. This research needs more student mastery of physics concepts. Based on some of the research mentioned earlier, remote learning can be used to increase students' conceptual understanding, even though remote learning could be better. This research used project-based remote learning to get around this problem. Project-based learning encourages students to learn knowledge and is skilled in preparing complex questions, real questions, and products [17], [18]. Project-based learning is a collaborative and inclusive learning method that allows students to think freely and creatively [19]. The existence of project assignments is believed to improve students' mastery of concepts. Experimental-based project-based learning effectively increases concept mastery and student performance [20]. Previous research also supports this, which proves that project-based learning greatly influences the mastery of physics concepts in work and energy for class X Senior High School in Bengkulu City [21].

Based on the results of observations and interviews with teachers and tenth-grade students at MAN 1 Malang City, it is known that teachers have not been able to apply innovative learning models, as well as not maximizing the use of learning features that help students in learning physics in class. The teacher only relies on the Whats App Video Call. The teacher only relies on physics material to the extent of memorization for students. Students felt that learning physics was monotonous and just a theory, so students were bored during distance learning. Students also experience difficulties in mastering physics concepts, as evidenced by the results of the test scores on the previous material, which still get scores below the Minimum Completeness Criteria (MCC). That is due to the inability of students to solve problems in the problem. Student's difficulties in mastering physics concepts can be caused by the inappropriate selection of learning innovations [22], [23]. This is supported by research that has found that teachers still need to be more effective in providing practice questions so that students are less able to solve problems that exist in questions [24].

If these conditions are not given a solution, it will impact students' mastery of physics concepts that are not good. Therefore, researchers want to know how the project-based distance learning model influences students' mastery of concepts. This study uses a distance learning model with the Zoom, Email, and Whats App Group applications. The difference between this study and previous research is that it measures students' mastery of concept abilities. The learning process uses the project-based distance learning syntax, which consists of problem recognition, designing project plans, creating project schedules, implementing and monitoring projects, presentations, evaluations, and reflections. In doing a project, students are required to make a product design plan which is then presented. The following are the stages of project-based distance learning.

## II. Method

### Research design

The research design used is Mixed Method. According to Creswell [25], the mixed method combines quantitative and qualitative research. The design in this study uses the Embedded Experimental Model. Quantitative research in this study used the One-Group Pretest-Posttest Design, where in this design, there was one experimental group that was selected by measuring students' conceptual knowledge. Students mastery of concepts is measured by a pre-test to find out the initial state, given treatment, and finally given a post-test. At the same time, qualitative research in this study used interviews conducted before and after being given treatment. This study measured whether there was an effect of project-based distance learning on students' mastery of concepts. The following is the Embedded Experimental Model research design which has been interpreted by researchers with the research to be carried out shown in Figure 1.

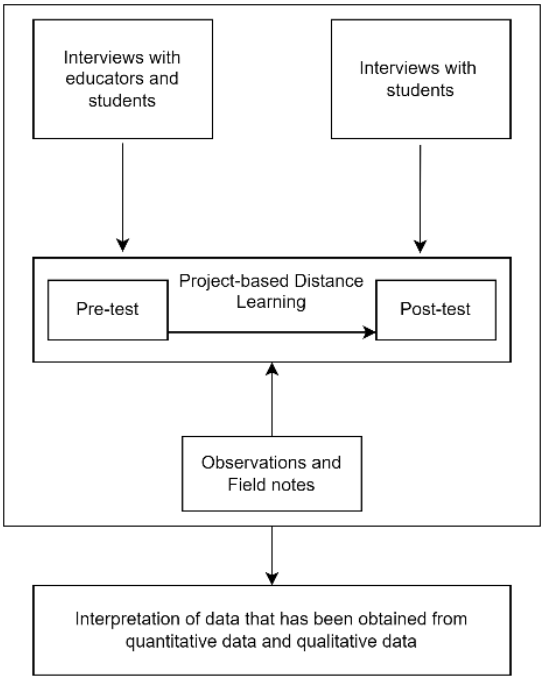


**Figure 1.** Research design

The subjects in this study were students of class X A 5 at MAN 1 Malang City in the 2021-2022 academic year. As many as 34 students were taken using the Cluster Random Sampling technique. The instruments used in this study were divided into treatment instruments (instruments related to the implementation of learning) and measurement instruments (instruments related to testing items describing mastery of concepts and interview guidelines).

Data collection techniques in this study were observed along with interviews and tests. Two quantitative data were obtained, namely the students' concept mastery test. While the qualitative data were obtained from interviews before the pre-test with the teacher and students and after the post-test with the students, the results of the pre-test and post-test answers, and the LKPD answers. The concept mastery essay test contains the relationship between work, force, and displacement, the application of potential energy, kinetic energy, and mechanical energy in everyday life. The instrument of concept mastery was made with 10 description questions which were validated by content and constructs by the physics lecturer. Then an empirical validation was carried out on 70 students of MAN 1 Malang City who had received material on effort and energy to determine the validity of the items, the reliability of the questions, the difficulty level, and discriminatory power. Analysis of the validity and reliability test using SPSS while the level of difficulty and power of difference test using excel.

Based on the results of testing the validity, reliability, difficulty level test, and different tests, the instrument questions used are 5-item description questions consisting of no. 1, 4, 7, 8, and 9. After the quantitative and qualitative data have been obtained based on the results, it is necessary to have a process for analyzing the

data. Quantitative data were analyzed by a different test with paired sample t-test, N-Gain analysis, and d-effect size. Analysis of the different tests and the normalized gain N-Gain test used SPSS, while the d-effect size used Excel. Qualitative data from interviews with teachers and students will be analyzed to support the quantitative data obtained.

### Learning Description

The learning implementation concerns the Learning Implementation Plan by applying a project-based distance learning model, carried out in three meetings via Zoom for 90 minutes. The learning stages are carried out to follow the syntax shown in Table 1.

**Table 1.** Project-based distance learning syntax

| Stages | Educator Activity | Student Activity |
|---|---|---|
| Problem Introduction | Educators ask questions (driving problems) related to practical problems (daily life). Educators can provide examples of cases/pictures/videos about everyday life problems to ask questions. In addition, record all questions asked by students. | Critical thinking, association (connecting natural phenomena with discussion topics), communication, and innovation. |
| Project Plan Design | Educators divide groups, explain each group member's responsibilities and roles, and guide each group to discuss the design project plan. | Students are looking for study reference materials. Online: Learning Houses, Youtube, e-books, etc. Offline: library textbooks, interviews, etc. Students draw up the overall project design. |
| Project Schedule Creation | Educators and students determine the project schedule (stages and implementation time). | Students in groups determine the project schedule as the steps for implementing the project. |
| Project Implementation and Monitoring | Teachers monitor the implementation of student projects in the following ways: WhatsApp, Facebook, Virtual Class, Google Classroom, etc. | Students work independently or have group discussions via video conferencing. Students will be given a worksheet as a guide to work on the project. Students record every stage of project implementation (photos, videos, and notes). |
| Presentation | Each group conveys the results of the product and is strengthened by the educator. | Students inform the results of project implementation. Other students give opinions, questions, or suggestions based on the results of other groups' presentations. |
| Evaluation and Reflection | Educators measure students' understanding through tests as an evaluation and reinforce concepts by reviewing the results of each group as a reflection. | Students submit results reports while other students respond while at the same time making conclusions with educators. |

Every day before learning is carried out, the teacher provides modules, LKPD, and learning videos via the Whatsapp group for students to study first. Then 15 minutes before the lesson starts, the teacher sends a Zoom link via the Whatsapp group.

#### *Meeting Learning #1*

Before learning for the 1st meeting begins via zoom, the teacher sends pre-test questions via the Whatsapp group on time when learning begins. Students work on pre-test questions for 20 minutes, and after doing so, students are asked to join zoom immediately. At the 1st meeting, the material discussed was the relationship between work, force, and displacement. The teacher reminded the material that had been obtained in the previous meeting, namely about Newton's Laws, by displaying an animation of an apple falling to the ground

from the tree. Most students answered that the force of gravity caused the apple to fall to the ground. Then the teacher reinforces by reminding the concept of Newton's Laws.

The teacher starts learning by conveying the learning objectives and conducting questions and answers regarding phenomena previously studied through animated videos. The teacher begins by asking questions, namely, "What is the difference between the animated events (a) and (b) in Figure 2? Based on animation (c), which method of pushing the eraser is the easiest to make the eraser move?"

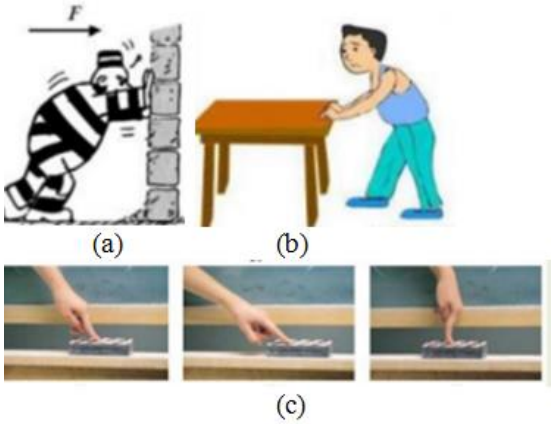


**Figure 2.** Animated physical phenomena

Most of the students revealed that in this phenomenon, both were pushing, but they could not explain the effort until the object moved or remained still. Then the teacher displays the three animations again by explaining them through force diagrams on each system and conveying material on displacement, force, and effort.

After that, the teacher conveys things about the project that will be assigned in groups by giving initial problems in the form of questions, namely, "Have you ever ridden a roller coaster? Then how can a roller coaster go at high speed without detaching from the rails? To solve these problems, the teacher gives project assignments by explaining the project framework that must be made. Then the teacher divides students into 5-6 groups to discuss and explain the assignment rules and collection time. The teacher also gives directions about the tasks to be done at home, namely LKPD-1 Work Concepts. The lesson ends with the teacher appealing to each group to collect the results of each discussion in the project assignments that have been made in the form of screenshots via email.

### *Meeting Learning #2*

At the second meeting, the sub-material discussed were potential, kinetic, and mechanical energy. The teacher recalled the material obtained at the previous meeting about the business concept by discussing the LKPD-1 task. In determining the value of effort, students experience difficulties determining the value of the angle formed, so the teacher guides students in determining the angle using the quadrant layout. In the next step, the teacher asks, "From the animation of people arching, is there a change in energy that occurs?" Some students answered that there was a change in energy but needed help explaining what energy had occurred. Some students answered that there was a change in the spring force when pulling the bow but needed to know what energy. Students cannot describe what energy occurs in the animation, so the teacher helps students to describe every movement made by the archer, starting from pulling the bow arrow to the arrow stuck in the board. The teacher questions the progress of the project assignment. Each group conveys the constraints and progress of completing the task. The teacher also gives directions about the tasks to be done at home, namely LKPD-2 about kinetic and potential energy. The lesson ends with the teacher urging each group to be able to work on project assignments outside the meeting so that at the next meeting, there will be improvements that can be delivered.

### *Meeting Learning #3*

At the third meeting discussed the project tasks. Each group collects the results of each group's presentation recordings on the WhatsApp group one day before learning begins. The teacher reminded again

of the material obtained at the previous meeting, namely about energy, through a discussion of LKPD-2 assignments. In determining the kinetic energy, students have difficulty choosing the largest kinetic energy based on the observational data obtained, so the teacher guides students by analyzing what quantities affect kinetic energy.

The next step, namely, the teacher starts the lesson with questions and answers related to responses in the form of comments or questions made on the results of testing other group projects collected through the Whatsapp Group the day before. Students describe the design of a roller coaster project by analyzing mechanical energy at several points. Each group has various ideas for making roller coaster projects. One of the things discussed is that there are groups that only determine the value of each potential energy and kinetic energy, so the teacher guides them to prove that the mechanical energy at every point is the same. There was also a group that commented on other groups regarding how to present where when explaining, they only read the text and did not understand the issues discussed, so the teacher gave feedback on how to present properly and correctly. Then the teacher reinforces the material that has been studied today to students, allows students to ask questions, and provides motivation to students who are less active in learning. The teacher ends the lesson via Zoom and provides post-test questions via the Whatsapp Group. Students work on post-test questions for 20 minutes. The questions are individual to determine how far the students have mastered the concept.

## III. Results and Discussion

### Results

Based on the results of interviews with students and teachers before the pre-test, it was stated that the learning method used by the teacher while distance learning was implemented still explaining material through WhatsApp video calls which were divided into several groups and assigned assignments. The results of interviews with ten students stated that they did not like studying physics because physics was considered a complicated subject. Students must study solid physics material, memorize, calculate, and understand non-contextual physics learning independently at home. However, some students think that learning physics is fun if they understand the material and use a lot of technology in learning so that it is interesting.

Before being given the treatment, the students worked on the pre-test, and after being given the treatment, the students worked on the post-test with the same 5-item description questions to measure students' mastery of concepts on work and energy material. The lowest concept mastery pre-test score obtained by students was 36, while the highest pre-test score obtained by students was 72. The lowest concept mastery post-test score obtained by students was 81.6, while the highest post-test score obtained by students was 97.6. Figure 3 is the data on students' average scores in answering pre-test and post-test questions.

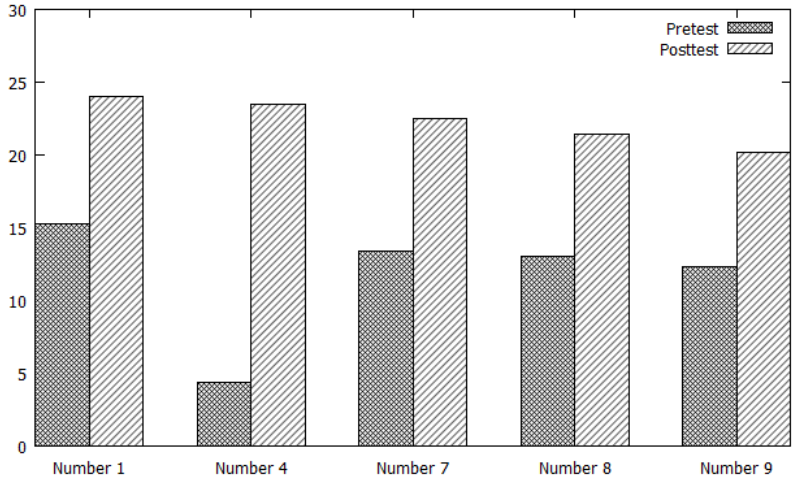


**Figure 3.** Diagram of the mean scores of students who answered the pre-test and post-test

The Shapiro-Wilk test was originally used to determine if the pre-test and post-test data for mastery of the material notion of work and energy were normal. The pre-test data normality test results had a significance value of 0.754, while the post-test data was 0.139. Because the significance value is > 0.05, the pre-test and

post-test data are normally distributed. Then the students' concept mastery test results were analyzed by conducting a different test with paired sample t-test. Following are the results of the paired sample t-test.

**Table 2.** Paired sample t-test

| | Mean | Std. Dev | Std. Error Mean | t | df | Sig |
|---|---|---|---|---|---|---|
| Pre-Post | -43.324 | 11.630 | 1.995 | -21.721 | 33 | 0.0000 |

Based on the concept mastery test analysis, a significance result of 0.000 was obtained, which means less than 0.05. This shows that the existence of a project-based distance learning treatment has a significantly different pre-test and post-test scores. After analyzing the difference test, a normalized gain test (N-Gain) was carried out to determine the increase in changes in students' mastery of concepts before and after being given treatment. The average N-Gain value is 0.766. So the increase in value is included in the high category.

Furthermore, to determine the magnitude of the influence of project-based distance learning in increasing mastery of the concept of work and energy, a d-effect size calculation is carried out. The result of calculating the d-effect size is 2.33, which is included in the strong effect category. This means that project-based distance learning has a strong influence on increasing students' mastery of the concept of effort and energy. Students' mastery of concepts in all sub-materials focused on in this study generally experienced a high increase. The questions on the "business concept" sub-material are represented by question number 1, the "potential energy" sub-material is in question number 4, and the "kinetic energy" sub-material is in question number 7. Furthermore, the "mechanical energy" sub-material is represented by questions 8 and 9.

The results of interviews with students support the pre-test and post-test data analysis after the post-test. The results of interviews with students who aimed to explore the extent to which students' ability to work on the concept mastery test questions stated that when working on the pre-test questions on work and energy material experienced difficulties. The question difficulty is regarding the stages of completion and the material discussed. Not only that, but students also revealed that after implementing project-based distance learning, students understood business and energy material more easily. When students were asked which activities helped in mastering the physics concepts that had been given, students explained that there was work on and discussion of the worksheet assignments given at the previous meeting. When working on the problem, the stages of work are given to make it easier to solve the problem. This can be known based on the interpreting stage, determining the concept appropriate to the problem in the problem. Then at the exemplifying stage, describes the problem and relate it to the concept. Classifying and recording any information in the problem. Then comparing, calculating it mathematically, and summarizing and explaining, namely writing down the results of the calculations and relating them to the material concepts of work and energy.

## Discussion

Based on the results of data analysis, it is known that the application of a project-based distance learning model can affect students' mastery of concepts on work and energy material. Improved mastery of concepts is evident from the results of the paired sample t-test, which shows a significant difference between pre-test and post-test scores. Changes in student mastery of concepts can also be seen from the results of the N-gain calculation of 0.766. It can be said that the increase in value is included in the high category, and the d-effect size of 2.33 is included in the strong effect category, which means that the treatment of the project-based distance learning model has an impact very strong on the mastery of the concept of work and energy [26], [27]. Based on previous research, project-based learning can help students improve their mastery of concepts [28]. Project-based learning can also be done with distance learning which is highly dependent on technology [29]. This is in line with research proving that project-based learning that applies technology effectively increases secondary school students' conceptual mastery and creative thinking skills [30].

There is an increase in students' mastery of the concept of work and energy caused by the project-based distance learning model applied in learning that goes well. This is supported by the suitability of the learning design that has been determined and the existence of learning tools that support students' exploratory activities in the form of working on worksheets to deepen their mastery of concepts. Learning by using a project-based learning model can encourage students to be more active because students gain cognitive, social, affective, psychomotor, and other skills, encourage students to engage in original works and tasks in depth and actively, and find new solutions that utilize more many resources more broadly as well as knowledge sharing,

collaboration [31], [32]. In addition, this model also allows students to have the opportunity to formulate their own learning needs so that they become independent and involved students who can solve problems through several stages, namely problem recognition, designing project plans, creating project schedules, implementing and monitoring projects, presentation, evaluation and reflection [33].

The analysis results based on students' mastery of concepts on work and energy material through the pre-test and post-test results experienced several improvements. Next, a qualitative analysis will be carried out on item number 7 to represent the increase in height.

### *Question number 7*

Question number 7 (see Figure 4) has a difficulty level of 0.4217 in the medium category, and the item difference power is 0.2244 in the good category. In item number 7, the phenomenon of applying kinetic energy in everyday life is given. A child pushes a shopping trolley to move in a straight, uniform motion. This question is intended so that students can determine the amount of change in kinetic energy that occurs.

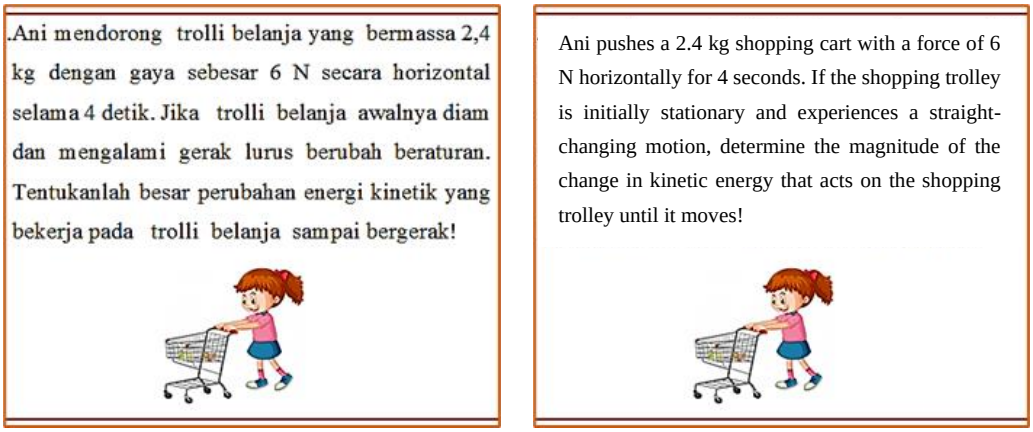


**Figure 4.** Kinetic energy sub-material questions

The following presents the crosstabulation of pre-test and post-test data for question number 4 for each item indicator, which includes interpreting (IN), exemplifying (EX), classifying (CLA), comparing (COM), summarizing, and explaining (SE). The crosstabulation of student answers on the Interpreting indicator is shown in Table 3.

**Table 3.** Crosstabulation of student answers on interpreting indicators

| IN | | Post-test | | | | | | Total |
|---|---|---|---|---|---|---|---|---|
| | | **0** | **1** | **2** | **3** | **4** | **5** | |
| **Pre-Test** | **0** | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | **1** | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | **2** | 0 | 0 | 0 | 0 | 0 | 2 | 2 |
| | **3** | 0 | 0 | 0 | 0 | 5 | 9 | 14 |
| | **4** | 0 | 0 | 0 | 0 | 6 | 10 | 16 |
| | **5** | 0 | 0 | 0 | 0 | 1 | 1 | 2 |
| **Total** | | 0 | 0 | 0 | 0 | 12 | 22 | 34 |

Based on the results of the student's answers in Table 3, it was stated that only two students answered correctly during the pre-test. At the same time, 32 other students answered incorrectly. However, when answering the post-test, some students answered correctly. There were also a few errors following the results of student interviews, which revealed that students needed help deciphering the concept of kinetic energy contained in the problem. After obtaining the material taught by the teacher through a project-based distance learning model as well as LKPD assignments, students find it easier to answer questions. This is in line with previous research, which states that learning physics has so many physical science concepts that are so difficult for students to understand theoretically, so learning media is needed to understand these concepts; one of the media that can be used is practicum [34]. The crosstabulation of student answers on the Exemplifying indicator is shown in Table 4.

**Table 4.** Crosstabulation of Student Answers on Exemplifying Indicators

| EX | | Post-test | | | | | | Total |
|---|---|---|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 3 | 4 | 5 | |
| Pre-Test | 0 | 0 | 0 | 0 | 1 | 4 | 10 | 15 |
| | 1 | 0 | 0 | 0 | 3 | 4 | 1 | 8 |
| | 2 | 0 | 0 | 0 | 1 | 2 | 3 | 6 |
| | 3 | 0 | 0 | 0 | 0 | 0 | 3 | 3 |
| | 4 | 0 | 0 | 0 | 0 | 1 | 1 | 2 |
| | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | | 0 | 0 | 0 | 0 | 5 | 11 | 18 |

Based on the results of the student's answers in Table 4, during the pre-test, most of the students had difficulty connecting the concept of kinetic energy with the problem. However, during the post-test, students experienced a shift in their answers, being able to describe and relate changes in kinetic energy, where 18 students were able to answer correctly and 16 students needed to be more right or made a few mistakes. When the teacher asked about students' difficulties associating concepts with problem questions, most students answered that they had difficulty applying their knowledge of kinetic energy in solving problems. Regarding questions, students must understand the readings, symbols, and known variables and arrange them in the form of comparisons with the condition that there are variables that change in value. In addition, it requires the ability to predict trends according to certain data as consequences and implications that align with existing conditions [35]. The crosstabulation of student answers on the classifying indicator is shown in Table 5.

**Table 5.** Crosstabulation of Student Answers on Classifying Indicators

| CLA | | Post-test | | | | | | Total |
|---|---|---|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 3 | 4 | 5 | |
| Pre-Test | 0 | 0 | 0 | 0 | 1 | 4 | 10 | 15 |
| | 1 | 0 | 0 | 0 | 3 | 4 | 1 | 8 |
| | 2 | 0 | 0 | 0 | 1 | 2 | 3 | 6 |
| | 3 | 0 | 0 | 0 | 0 | 0 | 3 | 3 |
| | 4 | 0 | 0 | 0 | 0 | 1 | 1 | 2 |
| | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | | 0 | 0 | 0 | 5 | 11 | 18 | 34 |

Based on Table 5, most students can apply procedures according to the problems in the questions. This follows the results of student interviews, which said the easy-to-understand stage was the classifying stage because students could classify any information contained in the problem. Therefore, the most important thing for students to learn is that equations do not only function as calculation tools but also as conceptual organizers [36]. Students being able to see that each topic they are studying is a coherent structure with some powerful and productive core ideas rather than a large collection of unrelated facts to be memorized is a fundamental epistemological lesson [37]. The crosstabulation of student answers on the Comparing indicator is shown in Table 6.

**Table 6.** Crosstabulation of Student Answers on Comparing Indicators

| COM | | Post-test | | | | | | Total |
|---|---|---|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 3 | 4 | 5 | |
| Pre-Test | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 2 | 0 | 0 | 0 | 0 | 5 | 7 | 12 |
| | 3 | 0 | 0 | 0 | 3 | 7 | 11 | 21 |
| | 4 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | | 0 | 0 | 0 | 3 | 8 | 18 | 34 |

In the pre-test answers in Table 6, all students answered incorrectly. Only one student had a few errors. But when the post-test, 18 students answered correctly, 13 students made a few mistakes, and only three needed

to be corrected. So, students experienced a shift in answers for the better. Based on the results of interviews, students stated that when doing the pre-test, they needed help to answer the relationship between translational motion and kinetic energy. In addition, students also need more mastery of the relationship between force, acceleration, and speed. This is due to needing help remembering the material taught before. Not only that, but some students experience the wrong formulation, let alone calculations. Student analysis errors can be divided into three types, namely conceptual, procedural, and technical errors [38]. The crosstabulation of student answers on the Summarizing and Explaining indicator is shown in Table 7.

**Table 7.** Crosstabulation of student answers on the summarizing and explaining indicators

| SE | | Post-test | | | | | | Total |
|---|---|---|---|---|---|---|---|---|
| | | **0** | **1** | **2** | **3** | **4** | **5** | |
| **Pre-Test** | **0** | 0 | 0 | 0 | 1 | 2 | 5 | 8 |
| | **1** | 0 | 0 | 0 | 1 | 5 | 2 | 8 |
| | **2** | 0 | 0 | 0 | 3 | 7 | 1 | 11 |
| | **3** | 0 | 0 | 1 | 1 | 2 | 3 | 7 |
| | **4** | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | **5** | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Total** | | 0 | 0 | 1 | 6 | 16 | 11 | 34 |

Based on Table 7, the students' answers above, it can be seen that during the pre-test, 27 students had difficulty associating the concept of kinetic energy, and the calculation results were obtained by getting a score of 0-2. Only seven other students needed to be more precise in calculations or preparation of new solutions to the concept of kinetic energy. In the results of the interviews, students experienced difficulties in explaining the relationship between the problem and the solution. In addition, it is also difficult for students to understand concepts, the low way of thinking of analytical students is caused because students need to be used to applying physics concepts in real life. So the teacher must ensure that students understand the concepts, principles, and theories of physics through the learning process that has been given [39]. Someone with this understanding can think scientifically and apply scientific knowledge and skills when dealing with individual and social problems [40].

The findings in this study are that giving project assignments to students can affect students' creative abilities. The project task used is to make a roller coaster design which is then presented as creatively as possible. The results of student presentations are assessed using an assessment rubric that has been made according to creativity indicators. The assessment rubric has four indicators: fluency, flexibility, original thinking, and detailed thinking skills (elaboration), with a score of 1-4 each. Based on the assessment results, the results are presented in Table 8.

**Table 8.** Results of student creativity ability

| Indicator | Results | |
|---|---|---|
| | **%** | **Category** |
| *Fluency* | 85.2 | Very high |
| *Flexibility* | 75.0 | High |
| *Originality* | 80.1 | High |
| *Elaboration* | 75.7 | High |

Based on the calculation in Table 8, students' creative abilities are high. In the first indicator, fluent thinking, students can provide many answers, but the answers given are also varied and experience flexibility. The 3rd indicator of original thinking skills (originality) of students' abilities is high because students provide new ideas in making project designs. Then on the indicator of detailed thinking skills (elaboration), students' abilities are high because students have confidence when presenting and the courage to have answers that are different from their friends. The following is an example of student answers that represent the originality aspect in Figure 5.

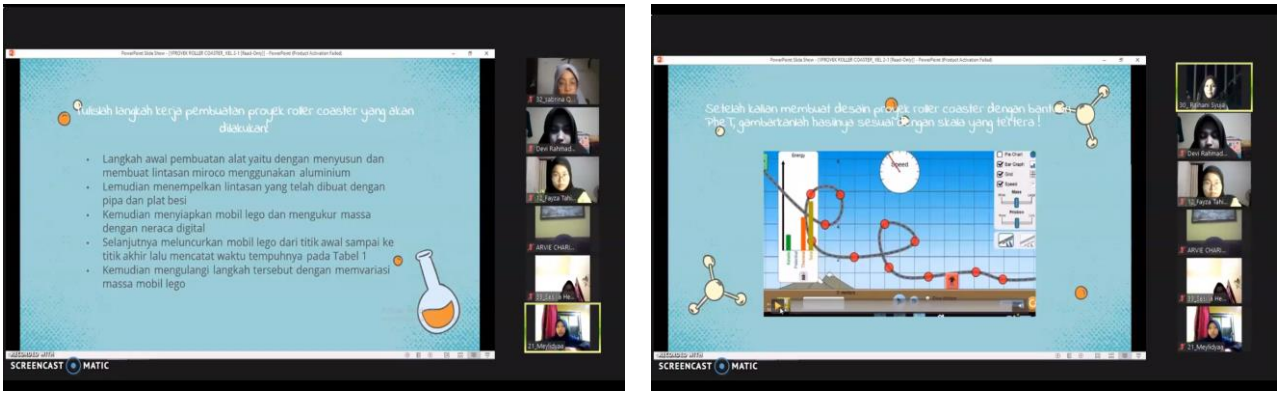


**Figure 5.** Example of student answers on the originality aspect

This explains that the originality aspect is an aspect that has very good ratings because the student can make the initial design before the tool is made in its actual form. In this aspect, the assessment of student project results is based on the students' elaboration in generating original ideas. The students designing these items on laptops create roller coaster track layouts reflecting their ingenuity. This was done because, in a pandemic situation, these students could not work on making their tools outside the home, so one of these students and his group mates made their products virtually with the help of PhET.

Based on the results of student interviews, it was revealed that students needed help proving the concept of mechanical energy due to the absence of actual shape-making when completing project assignments. Many students need help analyzing the energy of each point in the project design. Therefore the teacher advises students to apply PheT in roller coaster track designs. PhET Interactive Simulation is very well designed to help students learn [41], [42]. Students can also learn to operate virtual equipment to significantly help them minimize errors using real tools when working on projects.

Applying the distance learning model increases students' enthusiasm for learning business and energy materials. This can be proven from the results of student project assignments that are very creative even though they don't make the product. The results of student interviews revealed that the application of project-based learning when learning physics is more fun because it can explore more creative ideas for learning physics. Classes taught using project-based distance learning achieve creative thinking skills in four aspects of creative thinking skills such as high curiosity, imagination, persistence, and discipline [43]. Therefore, project-based distance learning can increase student creativity.

The existence of an assessment of project results classified as high based on an average indicator value of 79% can prove that project-based distance learning affects student creativity. Student creativity can be seen in the results of observations of project performance and products [44]. Project-based learning with poster products can foster student creativity, as shown by observations of student work by the criteria listed on the observation sheet [45]. In addition, previous research also showed that based on the analysis of product observation sheets with a creative thinking scale, it could increase creativity, as evidenced by an average value of 84, which is classified as very high [46].

## IV. Conclusion

The project-based distance learning model significantly affects the mastery of concepts in work and energy. The effect of this model on increasing students' mastery of concepts is very strong. This is evidenced by the d-effect size value of 2.33. Furthermore, to determine the magnitude of the increase in mastery of the concept of work and energy, an N-gain calculation of 0.766 is carried out. Other supporting things are qualitative analysis with the help of crosstabulation and the results of student interviews, which state that students feel that students' mastery of concepts develops after participating in physics learning by applying a project-based distance learning model. The new thing that was found in this study was that the student's creative abilities showed a high category with an average indicator score of 79%. Based on the research results, project-based distance learning innovations can improve students' mastery of concepts, and even high student creativity can be found. Therefore this learning innovation is very effective in distance learning.

This research was conducted on religious-based state school students and showed a good increase in conceptual understanding. However, this research has yet to be applied to public or private schools to get a

more comprehensive picture. Therefore, we recommend applying it to public and private schools in future research.

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