

Building physics concept understanding and problem-solving ability in online learning through the concept attainment model

I Wayan Distrik^{1*}, Wawan Setiawan¹, Chandra Ertikanto¹

¹Physics Education Department, University of Lampung, Indonesia

*Corresponding Address: wayandistrik8@gmail.com

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ABSTRACT

This research aimed to build physics concept understanding and to problem-solve in online learning through the concept attainment learning model. This research employed a quasi-experimental method with a non-equivalent control group pretest-posttest design. The population was natural sciences students in grade XI of Public Islamic School 1 in Pringsewu, Lampung, Indonesia. The samples consisted of 35 grade XI students from class IPA 3 for the experimental group and 34 grade XI students from class IPA 2 for the control group. The concept understanding test consisted of ten problems referring to Anderson and Krotwall's indicators. The problem-solving test consisted of five problems referring to problems developed by Savage and William. The test results of physics concept understanding and problem-solving ability were analyzed descriptively by grouping the data, calculating the n-gain, and interpreting the data. The difference in physics concept understanding and problem-solving between experimental and control classes were analyzed using an independent sample t-test. The result showed that the n-gains of physics concept understanding and problem-solving ability were in the high and moderate categories, respectively, for the experimental class and the moderate and moderate categories, respectively, for the control class. The independent sample t-test showed that conceptual understanding and problem-solving ability differed significantly between the experiment and control classrooms. This result indicated that the concept attainment model in online learning was better for building physics concept understanding and problem-solving ability for senior high school students than other conventional learning models.

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INTRODUCTION

Since the beginning of 2020, the world, including Indonesia, has been facing a Covid-19 health crisis. The pandemic affects many fields, including education, so the offline learning process turns into online learning. Unlike offline learning, online learning can be done whenever and wherever (Adedoyin & Soykan, 2020). It is long-distance learning using internet media to send solutions to improve knowledge and skill (Johnson et al., 2020). Online learning enables teachers to

apply various learning models and strategies to achieve learning objectives via Zoom applications. Online learning activities can be carried out according to the learning scenario. It is just that the interaction between teachers and students cannot be done optimally.

In learning physics, students sometimes face complicated problems to solve because of their lack of concept understanding, both in physics and mathematical concepts. Not only do students in elementary, junior, and senior high school students find concept

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understanding difficult, but also first-year university students also experience this problem (Distrik et al., 2021). In understanding physics learning materials, students also find misconceptions about simple circuits (Küçüközer & Kocakulah, 2007; Demirci, 2006), electricity, and magnetism (Demirci, 2006; Luangrath et al., 2011).

A conceptual understanding is an ability a learner attains after learning (Effendi, 2017). Obtaining physics learning success is an absolute requirement (Purwanto & Sasmita, 2013). The concept is important in physics problem-solving (Mestre, 2001; Karpudewan et al., 2015). A similar notion is stated by Abdullah et al. (2014) that conceptual understanding can help problem-solving, and problem-solving will strengthen conceptual understanding, procedural fluency, strategic competence, productive disposition, and adaptive reasoning abilities.

One of the reasons why physics is difficult is that the concept is not well understood, which makes the problem-solving ability in physics and mathematics lower (Samudra, 2014). A good conceptual understanding would help students to solve the problem; otherwise, it would make them difficult to solve problems (Agustina, 2016; Distrik et al., 2021).

The online learning observation results in some schools in Pringsewu district, Indonesia, showed that physics learning used conventional methods by explaining the materials, providing examples of problems, and practicing with problems. These methods made it difficult for students to understand physics concepts and affected their physics problem-solving abilities, which lowered students' learning results. A learning model that can guide students in understanding concepts is required to improve physics concept understanding and problem-solving ability. Some learning models implemented to improve conceptual understanding and problem-solving ability, such as the Multiple Representation-based REAL models (Distrik et al., 2021) and Creative Inquiry-based

student worksheet (Wulantri et al., 2020), are not yet optimum, especially concerning the concluding indicator. Concept mapping of each concept should be discussed, which makes it difficult for students to remember too many concepts.

Learning physics should include memorizing and understanding many concepts so that each concept should be mapped and discussed thoroughly. One of the learning models to map concepts in detail is the concept attainment model. The concept attainment model is a learning model to improve students' conceptual understanding of a particular material (Sa'diyah et al., 2015). Mayer (2012) states that implementing the concept attainment model can maximize students' learning of a new concept. It can guide students to reconstruct a learning process by using problem examples to build a new concept for basic problem-solving.

According to Joyce & Weil (2003), concept attainment model steps consist of data presentation, data identification, concept attainment testing, and students' thinking strategy analysis. The concept attainment model effectively improves students' learning results (Putri et al., 2019). because each learning step always presents facts and events in the form of video or animation. Therefore, students are motivated and enthusiastic in explaining facts, classifying, comparing, predicting, and concluding (Anderson & Krathwohl, 2001)

Various previous studies on the concept attainment model have been widely carried out and succeeded in improving various things, such as mathematics learning outcomes (Sukardjo & Salam, 2020), mathematical critical thinking ability (Angraini & Wahyuni, 2020), mathematical, conceptual knowledge (Anupan & Chimmalee, 2022), science process skills (Halim et al., 2021), and conceptual understanding (Ifrianti et al., 2019). However, the results of the research showed a lot of mathematics learning. As for learning physics, it is limited to understanding the concept only. No research explains in detail

its effect on problem-solving. Therefore, this research fills that void with novelty by looking at conceptual understanding and problem-solving.

The problem of this research was ‘did the concept attainment model in online learning help senior high school students to improve physics concept understanding and problem-solving ability?’ This research aimed to improve the physics concept understanding and problem-solving of high school students.

METHODS

This research employed a quasi-experimental method with a non-equivalent control group pretest-posttest design (Fraenkel & Wallen, 2003). This research was done in Public Islamic High School in Pringsewu district, Lampung, Indonesia. The research population was grade XI natural sciences students for 2020/2021. The samples were 35 grade XI students in the IPA 3 classroom for an experimental class that applied the concept attainment learning model and 34 grade XI students in the IPA 2 classroom for a control group that used the conventional learning model (presentations and discussions). Both classrooms were taught with the same learning material, namely the static fluids. The research design, in general, is shown in Figure 1.

| | | |
|----------------|---|----------------|
| O ₁ | X | O ₂ |
| O ₁ | - | O ₂ |

Description: O₁= Pretest, O₂= Posttest, X= Treatment

Figure 1. Research Design

Data were collected with pretest and posttest containing ten multiple choices problems for the conceptual understanding test and five essay problems for the problem-solving test. Concept understanding indicators consisted of explaining, providing an example, comparing, and concluding (Anderson & Krathwohl, 2001). The indicators for the problem-solving test were setting up a model, analyzing the problem,

and interpreting and validating (Savage & Williams, 1990).

Before learning was started, both classrooms were tested for concept understanding and problem-solving ability to measure the initial abilities of students. After learning finished, posttests were conducted to measure students' final physics concept understanding and problem-solving abilities. Pretest and posttest data were analyzed descriptively by grouping test result data of each indicator and calculating size effect and n-gain. The size effect was calculated with the following formula:

$$d = \frac{\bar{X}_1 - \bar{X}_2}{S_{pooled}}$$

N-gain was obtained by subtracting the final test score from the posttest score and dividing it by the maximum score subtracted by the pretest score. The formula proposed by Hake (2002) is as follows:

$$g = \frac{S_{Post} - S_{Pre}}{S_{Max} - S_{Pre}}$$

An inferential test using an independent sample t-test was done to see the n-gain difference between experimental and control classes in concept understanding and problem-solving ability.

RESULT AND DISCUSSION

The concept attainment learning model was applied eight times in face-to-face meetings in the odd semester of 2021 (8 x 2 hours of lessons). The observation result by assisting teachers showed that the average concept attainment learning model implementation in the experimental class was 91.20%, which belonged to the high category according to the learning scenario. Before the model was applied, validity and reliability tests were done on the research instrument for concept understanding and problem-solving ability. The result showed that the instrument was valid with Sig. (2-tailed) lower than 0.05 and reliable with Cronbach's Alpha 0.866 for

the conceptual understanding test and 0.922 for the problem-solving ability test. The pretest and posttest results of conceptual

understanding and problem-solving ability in experimental and control classes are shown in Table 1.

Table 1. Pretest and Posttest Results of Concept Understanding of Experimental and Control (C) Classes.

| <i>Data</i> | <i>Pretest</i> | | <i>Posttest</i> | | <i>N-gain</i> | |
|------------------------------|----------------|-------|-----------------|-------|---------------|------|
| | E | C | E | C | E | C |
| Concept understanding | 39.86 | 42.94 | 80.15 | 68.09 | 0.70 | 0.43 |
| Problem-solving | 38.69 | 40,47 | 81,26 | 74,47 | 0.71 | 0.57 |

Description: E = Experimental, C = Control

Table 1 shows that both experiment and control classes improve conceptual understanding and problem-solving ability. However, the improvement of the experimental class with a concept attainment learning model is greater than the control classroom with a conventional learning model. The concept attainment learning model improved concept understanding because each syntax of this learning model trained, stimulated, and improved concept understanding. Concept attainment learning model application in physics learning eases students to identify, explain, differentiate, and group concepts. This finding is in line with Putri et al. (2019) that the concept attainment model implementation can improve student activity and learning outcomes. N-gain of physics concept understanding improvement in experimental class was 0.7, belonging to a high category, while n-gain in control classroom was only 0.43, belonging to the moderate category. The experimental classroom significantly had a higher n-gain than the control classroom in concept understanding. There are three important steps in the concept attainment model. The first is identification; in this step, students classify examples and non-examples of viscosity and capillary concepts. This step would strengthen students' memories about events relating to things and events concerning viscosity and capillary. In this

step, students can interpret, explain, classify, compare, and conclude events related to viscosity and capillary. The second step is concept attainment testing. In this step, students would find the solution to a problem to work. The third step is thinking strategy analysis, where this step, students would be guided to think about how to memorize concepts and find problem solutions.

This research result is relevant to the research finding by Putri (2017) that the concept attainment learning model can allow students to express ideas before answering problems by teachers and develop students' conceptual understanding of the related materials. Handayadi & Hidayati (2020) also suggest that the concept attainment learning model helps students develop abilities to understand concepts and solve problems. Putri et al. (2019) find that learning by implementing concept attainment significantly influences 43.8% of learning results. The attainment concept model is not only well applied offline but also online, although there are several weaknesses, especially in activities and interactions between teachers and students.

This shows that concept attainment implementation influences students' learning results. Pretest-posttest results and n-gain of each indicator of conceptual understanding of experiment and control classrooms are shown in Figures 1 and 2.

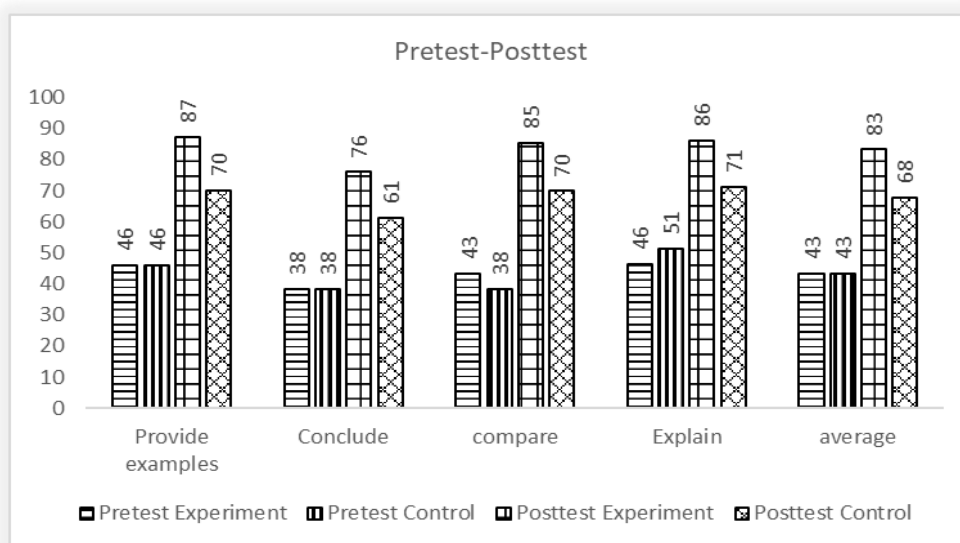


Figure 1. The average pretest and posttest results of concept understanding

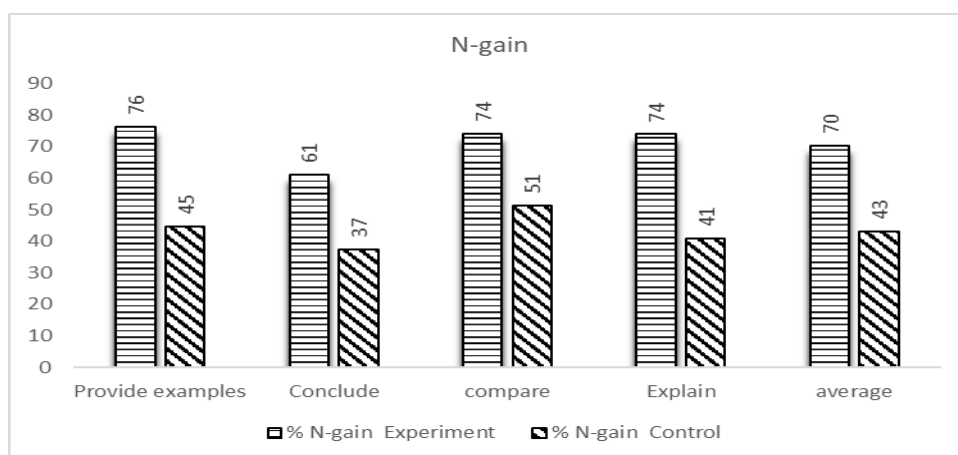


Figure 2. N-gain of concept understanding

Independent t-test result shows no difference in pretest results between experiment and control classrooms (sig. (2tailed) > 0.05) for each indicator. This means that initial students' abilities in concept understanding for each indicator do not differ significantly between experiment and control classrooms. Figure 1 shows that all indicators of conceptual understanding in experiment and control classrooms improve significantly after learning. There are improvements in the control classroom, but the n-gain of conceptual understanding in each indicator is lower (sig. (2 tailed) < 0.05)

compared to the experiment classroom. Figure 2 shows that the n-gains of the *concluding* indicator are the lowest in experiment and control classrooms. This is because students find difficulty analyzing data, even though they can collect and identify data properly. In learning, students can give examples and non-examples of a concept, and they can differentiate between one concept and another. Students' abilities in experiment classroom in concept understanding show high n-gains because the concept attainment learning model can guide students to display and explain data,

recognize concepts, provide examples and non-examples, compare a concept with another, and conclude, even though they seem to have a little difficulty in concluding. This difficulty is because of students' learning styles and online learning. Students with kinesthetic learning styles dislike online learning because they prefer direct interactions with teachers. Online learning is a little bit difficult for those students with visual and auditory learning styles because the visual and voice received by Zoom applications for online learning are not as good as direct learning. The limitation in online learning is also caused by the ability to access and use technology and the limitation of structure and infrastructure; these would cause unease in students' understanding of the

concept comprehensively, especially in concluding. This is because of the student's habit of never interpreting a problem that has just been solved so that the student still finds difficulties in making a final decision. Therefore, problem-solving should come to validation and interpretation steps to give meaning to each attained data by estimation and observation.

Although some students find difficulties in understanding concepts, problems with structure and infrastructure and learning style in online learning, students are so motivated to investigate animated figures to explain fluid concepts. The following are examples of students' investigations in displaying data or figures relating to the amount of pressure and depth (figure 3)

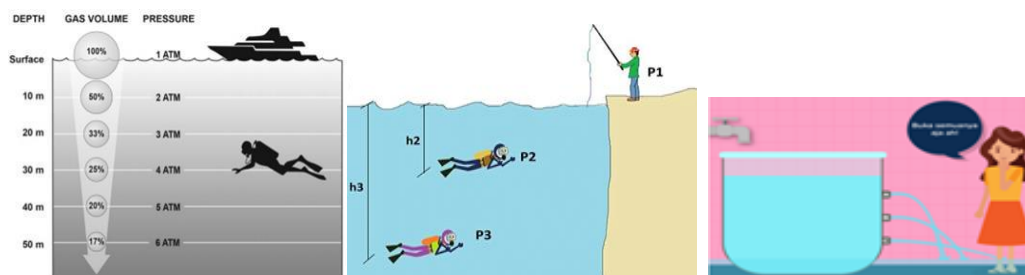


Figure 3. Relating the amount of pressure and depth

Students in groups display data according to their respective perceptions. Each group explains the pressure concept on static fluid verbally and graphically. Almost all groups explain that the amount of pressure is in line with the depth of the fluid. Still, they display different graphics with mathematical equations explaining the correlation between pressure (P) and depth (h), so there are cognitive conflicts. To overcome this problem, students are given some figures of examples and non-examples of the correlation between the pressure (P) and depth (h). Through the hypothetical test, the figures are easily recognized. In the last stage, an analysis of strategy is done to

prevent misconception by showing data of each variable and discussing them to obtain valid conclusions. Interactions between students in online learning through the Zoom application are rather limited, so the discussion cannot go optimally because the written explanation is a little bit difficult to do.

Besides improving concept understanding, the concept attainment learning model can also improve problem-solving ability (Figures 4 and 5). Results of pretest, posttest and n-gain of each indicator of problem-solving abilities in experiment and control classrooms are shown in Figures 4 and 5.

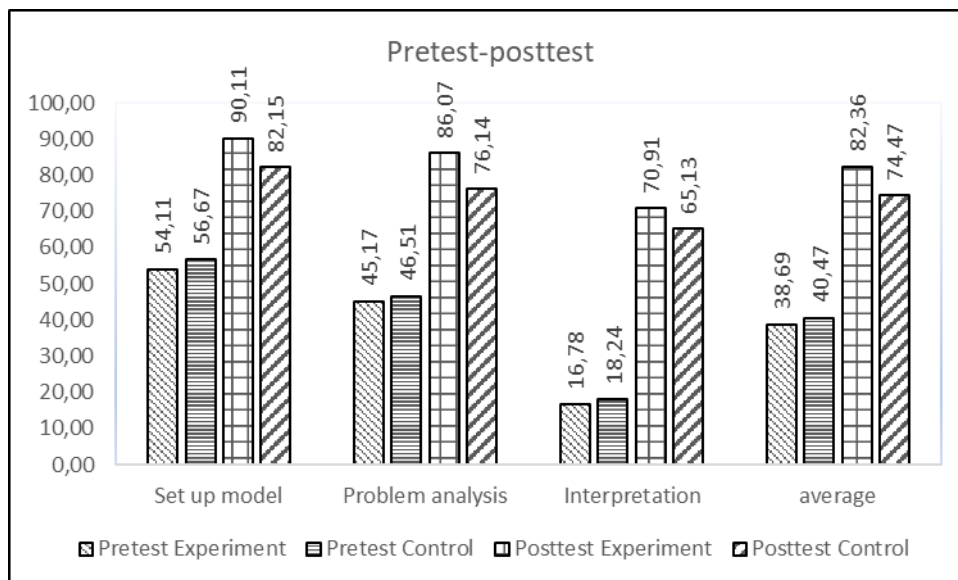


Figure 4. The average pretest and posttest results of problem-solving abilities

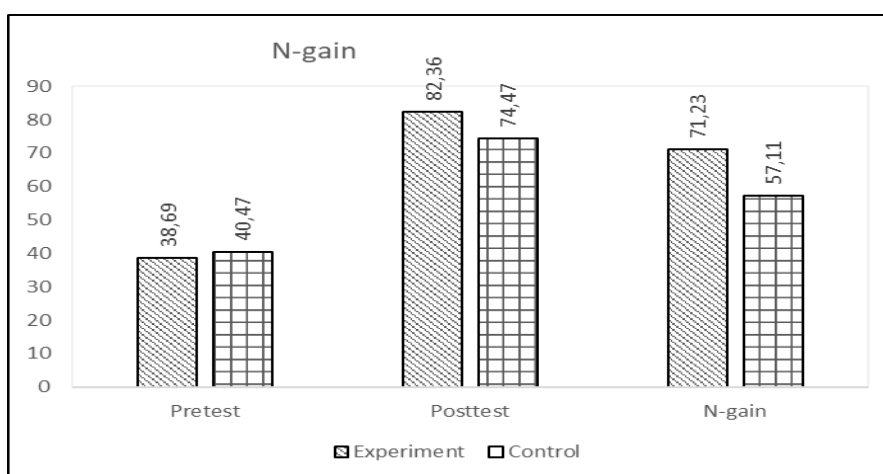


Figure 5. N-gain of problem-solving abilities

The physics problem-solving abilities of students taught with the concept attainment learning model belong to a high category. In contrast, those students taught with the conventional model belong to a moderate category. However, there is a significant n-gain problem-solving ability difference between experiment and control classrooms (sig. (2tailed) < 0.05). This is because learning using the concept attainment model can improve conceptual understanding. Concept understanding is important in physics problem-solving, and problem-solving ability strengthens concept understanding (Abdullah et al., 2014). A

research finding by Distrik et al. (2021) also suggests the correlation between conceptual understanding and problem-solving ability.

Online learning using concept attainment makes students a little bit difficult to do mathematical representation because of the limitations of the media to write or elaborate observation results mathematically. However, the concept attainment learning model can provide a learning space for students to do observations of an object virtually. It is easier to deliver examples and non-examples virtually so that students easily identify the key concepts and relationships amongst concepts. Student

physics problem-solving depends on the student's ability to apply a concept. A problem can't be solved in physics without understanding its concept properly. This research result also shows a positive influence of concept understanding on physics problem-solving ability (sig. (2 tailed) < 0.05). The concept attainment implementation in learning is very helpful for students to understand basic physics concepts and solve physics problems. The more students solve physics problems, the more they would strengthen their conceptual understanding.

CONCLUSION AND SUGGESTION

The concept attainment learning model, with data presentation, data identification, and concept attainment testing steps, has an important role in improving students' physics concept understanding and problem-solving ability with n-gains of 0.70 and 0.71, respectively, and they belong to the high category. Learning by using a conventional model can also improve conceptual understanding and problem-solving ability despite belonging to a moderate category with n-gains of 0.42 and 0.57, respectively. There are significant n-gain differences in concept understanding and problem-solving ability between students taught with the concept attainment model and those taught with the conventional model. There is a positive correlation between conceptual understanding and problem-solving ability. Applying the concept of attainment in physics learning online, some students have difficulty applying mathematics to solve problems. Therefore, using the concept of attainment in online learning, it is recommended that teachers continue to use the whiteboard and camera (smart class) or offline learning.

AUTHOR CONTRIBUTIONS

IW conceptualized the research design, WS conducted observations and made research instruments, IW and WS took

research data, CE analyzed the data findings and made discussions.

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