Application of Learning Model (LC) 7E with Technology Based Constructivist Teaching (TBCT) and Constructivist Teaching (CT) Approach as Efforts to Improve Student Cognitive Ability in Static Fluid Concepts

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Abstract. This study aims to get a representation of the students' cognitive abilities improvement on the concept of static fluid as a result of the application of learning cycle 7E with Technology Based Constructivist Teaching (TBCT). This research uses quasi experiment method with Pre-test Post-test Two Equivalent Group Design. The subjects were class XI students of academic year 2017-2018 as many as 56 students divided into 2 classes, 29 students of class XI IPA 1 as experimental class and 27 students of class XI IPA 2 as control class. Measurement of students' cognitive abilities used a multiple choice instrument test on the concept of static fluid. The data were collected using pre-test and post-test. The results showed that the learning of physics with learning model LC 7E with TBCT approach can significantly improve students' cognitive abilities on the concept of static fluid with n-gain value of 0.56 categorized medium compared to physics learning with learning model LC 7E with CT approach with n-gain value of 0.51 categorised medium. Hypothesis test results showed that there were no significant differences in students' cognitive abilities on the static fluid concept between students who received learning model LC 7E with TBCT approach with students who received learning model LC 7E with CT approach with a significance value of 0.217. Although there were no significant differences, the improvement in cognitive abilities of students in the experimental class was high compared to the control class.

1. Introduction
The educational objectives and development of the current quality of education should shift from simply meeting the value and graduation requirements to a broad understanding balanced with high cognitive and high-level skills. Physic learning should include the cognitive, psychomotor, and affective aspects supported by technology as a provision to continue education at a higher level and to develop science and technology in the future. Some efforts to realize the goal and the development of quality education that includes these aspects are the proper instructional learning one of them learning model LC. The LC model is one of the learning models that also use the constructivist approach as education in the world [1].

Learning cycle is a constructivism learning model developed by Robert Karplus in the Science Curriculum Improvement Study (SCIS) from the University of California, Berkeley in the 1970s [2]. In the beginning, the learning cycle model consists of 3 phases and is called learning cycle 3E consisting of exploration phase, concept introduction, and concept application. In 1980, Rodger W. Bybee developed a learning cycle learning model into 5 phases: engagement, exploration, explanation,
elaboration and evaluation [3]. Each "E" phase sequentially provides a learning experience to students in connecting prior knowledge with a new concept [4]. These five phases are then known as the 5E learning cycle. In its development, 5E learning cycle model has changed into 7E learning cycle. The addition of cycles in the learning cycle 7E is elicited and extended. In the 7E learning cycle, engagement is developed into eliciting and engaging. Elaboration and evaluation are developed to be elaborating, evaluating and extending so that the 7E learning cycle has elicited, engage, explore, explain, elaborate, evaluate and extend [5].

Previous studies conducted by Parasuma and Srikanta [6] in his research entitled Effect of Constructivist Teaching (CT) and Technology Based Constructivist Teaching (TBCT) on the Academic Achievement of Secondary School Student stated that learning with TBCT and CT approach can help learners in improve learning outcomes of learners, but TBCT is more effective than CT approach. According to Powell [7], technology is used to facilitate or mediate the learning process. Demirici [8] reveals that the use of simulation and animation for abstract topics makes learners more active in learning, providing opportunities for learners to build difficult concepts easier. The success of learning cycle 7E learning has been proven to improve cognitive learning outcomes, and students' generic science skills [9], can improve learning outcomes, critical thinking skills and students' science process skills [10], student learning result [11], can improve students' critical thinking skills [12], can improve students' understanding and achievement [13]. And can improve the ability to understand on the students who get the learning model of learning cycle 7E with approach of Technology Based Constructivist Teaching (TBCT) significantly higher than the students who get the learning model of learning cycle 7E with Constructivist Teaching (CT) approach [14]. Pre-test and post-test Chemistry Achievement Test (CAT) values indicate that 5E learning cycle and lecturer methods are increasing [15].

The role and influence of the media are integrated with the 7e learning cycle learning model where each phase has simulation and video activities

2. Experimental Method
2.1 Research Method
The method used is Quasi Experiment. In quasi experiments researchers should make use of existing intact groups [16]. The research design chosen was Pre-test Post-test Two Equivalent Group Design [17]. This design is done by giving the pre-test to know the cognitive ability of the student, then carry out the learning activity in the experimental class using learning cycle 7E with TBCT approach and the learning activity in the control class by using learning cycle 7E with CT approach. Then both classes are given the post-test with the same problem. The design in question is shown in the table 1.

| Classes  | Pretest | Treatment | Posttest |
|----------|---------|-----------|----------|
| Experiment | O₁  | X₁  | O₁  |
| Control   | O₁  | X₂  | O₁  |

Where: $O₁ = \text{Cognitive Ability Test}$, $X₁ = \text{Treatment was given to groups using Learning Cycle 7E with TBCT approach}$, $X₂ = \text{Treatment was given to groups using Learning Cycle 7E with CT approach}$.

2.2 Sample of Research
The population in this study includes all students of class XI SMA at Cerenti, Kuantan Singingi Regency in the even semester of 2017-2018 school year. The sample in this study were students from two classes of XI who were selected by purposive sampling, namely a method or sampling technique carried out with a specific purpose that is in accordance with the characteristics of the research subjects needed in this study, this is done because the whole class has the same characteristics (not there is a superior class) also students are taught by the same teacher [18]. So, it is obtained class XI IPA 1 as the experimental class and class XI IPA 2 as the control class.
2.3 **Variable of Research**
Variables in this study consist of independent variables and dependent variables. The independent variable is the instructional model of learning cycle 7E with TBCT approach, while the dependent variable is students' cognitive ability.

2.4 **Instrument of Research**
To obtain data and information needed in this research, researcher makes a set of research instrument. The test used is a cognitive ability test used to measure students' cognitive enhancement of the concept of static fluid. A multiple choice test of cognitive ability is 20 items with five choices (A, B, C, D, and E). The test forms used in the pre-test and the post-test are the same.

2.5 **Data Collection Techniques**
Data collection is done to obtain the information needed in order to achieve the research objectives. In this study, the data collection techniques are the means used to obtain empirical data that can be used to achieve research objectives. The data collection techniques conducted in this study is a test of cognitive ability. Giving pre-test aims to see the ability of students before getting treatment (treatment) learning activity learning cycle 7E with TBCT approach, while post test to see the results achieved by students after getting treatment.

2.6 **Data Analysis**

2.6.1 **Enhancing Cognitive Ability**
To see the improvement of students' cognitive abilities, an analysis of the n-gain score \( \bar{g} \) was carried out. Normalized gain scores can be expressed by the formula (1). [19].

\[
\bar{g} = \frac{\text{post test score} - \text{pre test score}}{\text{max score} - \text{pre test score}}
\]

(1)

Categories of students' cognitive abilities can be seen in table 2.

| Percentage | Category |
|------------|----------|
| 0.00 < \( \bar{g} \) ≤ 0.30 | Low |
| 0.30 < \( \bar{g} \) ≤ 0.70 | Medium |
| 0.70 < \( \bar{g} \) ≤ 1.00 | High |

2.6.2 **Hypothesis Testing**
Testing the hypothesis in this study using a two-tailed t-test (2-tailed) with a significant level of \( \alpha = 0.05 \), with the formula (2).

\[
t_{\text{count}} = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{(n_1 - 1)S_1^2 + (n_2 - 1)S_2^2}{n_1 + n_2 - 2} \left( \frac{1}{n_1} + \frac{1}{n_2} \right)}}
\]

(2)

Where: \( X_1 \) = N-gain average experiment class, \( X_2 \) = N-gain average control class, \( n_1 \) = number of experimental class students, \( n_2 \) = number of control class students, \( S_1 \) = experimental class variant, \( S_2 \) = control class variant.

With the testing criteria: if \( t_{\text{count}} > t_{\text{table}} \) then Ho is rejected at the significant level \( \alpha = 0.05 \) and the degree of freedom \( dk = n_1 + n_2 - 2 \), so Ha is accepted.

\( H_0 \) = \( \mu_1 = \mu_2 \) there is no average difference between the two classes

\( H_a \) = \( \mu_1 > \mu_2 \) the average experimental class is greater than the control class

Where: \( \mu_1 \) = the average experimental class, \( \mu_2 \) = the average control class.

3. **Result and Discussion**

3.1 **Result**

3.1.1 **Enhancing Cognitive Ability**
This study was conducted in the even semester of the academic year 2017-2018 for three meetings. In the experimental class, the learning model of learning cycle (LC) 7E with Technology Based Constructivist Teaching (TBCT) approach was applied, while the control class was given the treatment
of learning cycle learning model (LC) 7E with Constructivist Teaching (CT) approach. Prior to the
treatment, first test of the two classes to determine students' early cognitive abilities on the concept of
static fluid. Then apply the LC 7E learning model with TBCT approach to experiment class and LC 7E
learning model with CT approach to control class. After the treatment process is completed, the
activity ends with a final test that is intended to determine students' cognitive improvement on the
concept of static fluid. Research activities were purposed to obtain data about the initial test score and
the final test of students' cognitive abilities. Based on preliminary test score data and the final test can
be determined improvement of students' cognitive abilities through the calculation of n-gain $\bar{g}$.

The average pre-test score of cognitive ability of experimental class students before learning is
28 and the average post-test score of 68 with n-gain value $\bar{g}$ of 0.56 with medium criterion. While
the average initial test score cognitive ability of control class students before the learning of 27 and
the average final test score of 65 with n-gain value $\bar{g}$ of 0.51 with medium criteria. The n-gain value $\bar{g}$
in Hake is included in the medium criterion. This suggests that students' cognitive abilities of the
Static Fluid concept are increased by moderate category after treatment. The value of n-gain $\bar{g}$
experimental class given by LC 7E learning model with TBCT approach is higher than control class
given by LC 7E learning model with CT approach. Data cognitive ability of students can be seen in

Table 3. Result of pre test, post test, and n-gain values of cognitive ability of experimental class and
control class.

| Classes   | Pre test averages | Post test averages | n-gain $\bar{g}$ |
|-----------|-------------------|--------------------|------------------|
| Experiment| 28                | 68                 | 0.56             |
| Control   | 27                | 65                 | 0.51             |

Increased cognitive abilities of students on each aspect of cognitive can be known from the test
scores obtained by students on each item given in the initial test and final test. The number of
questions used consists of 20 items of multiple choices with 5 choices (A, B, C, D, and E). There are
four cognitive aspects that are made in the research instrument made on the concept of Static Fluid ie
cognitive aspects of C1 (remember), C2 (understand), C3 (applying), and C4 (analysing). The pre-test
score, post-test, and the n-gain value $\bar{g}$ of the experimental class on each cognitive aspect can be
seen in Figure 1.

**Figure 1.** Pre-test and post-test score, and n-gain values each cognitive aspect of the experimental
class. Remember (C1), understand (C2), applying (C3), analysing (C4)

The average cognitive abilities of students in the experimental class in each aspect of the
diagram increase. The ability to remember C1 has the highest increase with n-gain of 0.74 which is
included in the high category. This shows that the experimental class students are able to remember
the concept of hydrostatic pressure, Pascal law, and Archimedes law well. The ability of students to
analyse C4 has the lowest increase with n-gain of 0.31 which belongs to the medium category. This means that the ability of experimental class students to analyse the concept of static fluid is still low. Pre-test and post-test score, and n-gain values each cognitive aspect of the control class are shown in figure 2.

\[\text{Figure 2. Pre-test and post-test score, and n-gain values each cognitive aspect of the control class.}\]

Remember (C1), understand (C2), applying (C3), analysing (C4).

Similar to the experimental class, the average pre-test, post-test, and n-gain scores of control students in each aspect of the diagram also increased. The ability to remember C1 has the highest increase with n-gain of 0.69 which is included in the medium category. This shows that the control class students are quite capable of remembering the concepts of hydrostatic pressure, Pascal law, and Archimedes' law well. The ability of students to analyse C4 has the lowest increase with n-gain of 0.22 which belongs to the low category. This means that the ability of control class students to analyse the concept of static fluid is still low.

To see the differences in cognitive enhancement of each aspect between the experimental class and the control class can be seen in the Table 4.

\[\text{Table 4. Comparison of n-gain values of cognitive ability of experimental class and control class on each aspect of cognitive ability.}\]

| Classes   | n-gain |
|-----------|--------|
|           | C1  | C2  | C3  | C4  |
| Experiment| 0.74 | 0.71| 0.55| 0.31|
| Control   | 0.69 | 0.65| 0.47| 0.22|

Table 3 shows that cognitive abilities in both classes are equally improved but the experimental class has a higher increase than the control class in every aspect of cognitive ability.

3.1.2 Hypothesis testing

Before testing the hypothesis, it is necessary to test the normality and homogeneity of the distribution of data on the average score of n-gain cognitive abilities obtained by students to determine whether the sample used in the study came from a population that was normally distributed and homogeneous. Based on the results of the calculation, data is obtained as shown in the Table 5.

\[\text{Table 5. Normality and Homogeneity Test Results Related to Students' Cognitive Ability in Experiment and Control Classes.}\]

| Classes   | N | Normality Test | Homogeneity Test |
|-----------|---|----------------|------------------|
|           |   | Sig  | Category    | Sig   | Category  |
| Experiment| 29| 0.10 | Normal      | 0.92  | Homogeneous|
| Control   | 27| 0.42 | Normal      |        |           |
Table 5 shows that from the normality test related to students' cognitive abilities by using data on average n-gain scores in the experimental class total 29 students and control class 27 students, the significance values of normality were 0.10 and 0.42 respectively. This value indicates that the sample comes from a normally distributed population. Homogeneity test is done after it is known that the sample comes from a population that is normally distributed. The result of homogeneity test using the data of the average score of n-gain cognitive abilities obtained a significance value of 0.92. This significance value is greater than the significance level (α = 0.05) so that this value indicates that both samples have the same (homogeneous) variant.

Based on the normality and homogeneity test which states that the data is normally distributed and homogeneous, the hypothesis testing can be done using parametric tests using t-test (independent samples test) which is processed with the help of SPSS Statistic 24 data processing software. The results of hypothesis testing can be seen in Table 6.

| Equal variances assumed | Significance level (α) |
|-------------------------|-----------------------|
| 0.217                   | 0.05                  |
| 0.218                   |                       |

Table 6. Hypothesis Test Results for Increasing Students' Cognitive Ability.

Based on the results of hypothesis testing shown in table 6, Equal variances assumed with the value Sig. (2-tailed) of 0.217, this value is greater than the significance level (α) of 0.05. Then according to the basis of decision making in the Independent Sample T-Test test it can be concluded that Ho1 is accepted and H11 is rejected. This means that the hypothesis of this study is that there is no significant difference in students' cognitive abilities on the static fluid concept between students who get 7E learning cycle learning with a TBCT approach with students who get 7E learning cycle learning with a CT approach.

3.2 Discussion
3.2.1 Enhancing Cognitive Ability
Based on the results of the tests performed in Table 2, there was an increase from the initial test to the final good test in the experimental class and control class. The n-gain value in the experimental class is 0.56 while in the control class is 0.51, this value is included in the medium criterion. This shows that the improvement of cognitive ability in experimental class given by LC 7E learning model with TBCT approach is higher than control class given by LC 7E learning model with CT approach.

The cognitive abilities of students in every aspect of cognitive are quite good, as evidenced by the improvements that occur in every aspect that is tested against the students. In Figure 1, the difference between the pre-test and post-test average of the experimental class students is shown. Students' cognitive abilities experienced the highest increase in C1 of 0.74 and the lowest increase in C4 that is 0.31. This shows that students find it difficult to solve the problem along with the level of cognitive abilities that are tested.

Figure 2 also occurs in the same case as the experimental class, where there is a difference of pre-test and post-test grade values of the control class students. Students' cognitive abilities experienced the highest increase in C1 of 0.69 and the lowest increase in C4 is 0.22. This shows that students' cognitive abilities on the cognitive aspects of C4 (analysis) are still low. The low cognitive abilities in C4 were due to lack of continuous training on aspects of analysis. This is seen when students have finished experimenting based on LKS then it is considered able to analyse the concepts of static fluid or has finished doing tasks based on existing applications in learning. However, the graph shows that the overall cognitive abilities of the experimental class students are higher than the control class in each dimension of cognitive abilities tested. This is caused by learning in the experimental class assisted with PhET programs and learning videos that explain and exemplify
concepts related to static fluid phenomena while the control class must test experiments and analyse them by searching in textbooks.

In table 3, it can be seen that the increase of n-gain value of each aspect of the experimental cognitive ability of the experimental class is higher than the control class. This shows that the experimental class given by LC 7E learning model with TBCT approach is significantly more influential than control class given by LC 7E learning model with CT approach. This is consistent with research conducted by Parasuma and Srikanta [6] that CT and TBCT Interventions help students to perform better in post-test. The TBCT approach is more effective than the CT approach to improve student achievement. Resti [14] showed that there was an increase in comprehension ability with a normalized gain score $<\bar{g}>$ for the experimental class of 0.51, moderately higher than the control class of 0.33.

3.2.2 Hypothesis testing

In general, the improvement of students' cognitive abilities between the experimental and control classes did not differ significantly, both the experimental class and the control class both experienced an increase in cognitive abilities in the medium category. This does not mean that there is no difference at all but there are differences but not significant. This shows that students' cognitive abilities can be improved by applying the 7E learning cycle with both TBCT and CT approaches.

Although there were no significant differences, the improvement in cognitive abilities of students in the experimental class (TBCT) was higher compared to the control class (CT). This is due to technological assistance in the form of PhET programs in the application of 7E learning cycle learning models students become facilitated in training cognitive abilities because students become easier to find and to determine answers to questions in learning. As stated by Munir [20] that simulation on a computer is useful to explain a complicated relationship about a concept. Kocakaya et al. [21] also carried out research using computer assisted instruction whose use was applied to the 7E learning cycle learning model proven to improve the ability to understand prospective teacher students. Parallel findings were also obtained from Suci et al. [22] which states that the application of learning based on PhET simulation and optical KIT using direct learning models can complete student learning outcomes. According to Alessi and Trollip [23] "ICT-based learning has many advantages. One of them is that the advantage of using the time used becomes more effective, the subject matter becomes more accessible, attractive, and inexpensive.

4. Conclusion

Based on the analysis and discussion of students' cognitive abilities on the concept of static fluid, it can be concluded as follows:

Overall students' cognitive abilities improved with moderate criteria. Improvement of cognitive ability of experimental class students given by LC 7E learning model with TBCT approach is equal to 0.56 higher than control class given LC 7E learning model with approach of CT equal to 0.51.

All aspects of cognitive ability have improved. The cognitive aspects of C1 in the experimental class were 0.74 and control classes 0.69, C2 in the experimental class of 0.71 and control classes 0.65, C3 in the experimental class 0.55 and control classes 0.47, and C4 in the class experiments of 0.31 and control classes 0.22.

Hypothesis testing results show that there is no significant difference in students' cognitive abilities on the static fluid concept between students who get 7E learning cycle learning with the TBCT approach with students who get 7E learning cycle learning with a CT approach with Sig. (2-tailed) of 0.217, this value is greater than the significance level ($\alpha$) of 0.05. Although there were no significant differences, the improvement in cognitive abilities of students in the experimental class was high compared to the control class.

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