Advances in Social Science, Education and Humanities Research, volume 440
International Conference on Online and Blended Learning 2019 (ICOBL 2019)

The Usage of Virtual Laboratory on Grade 11 Students' Learning Outcomes Toward Physics

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Abstract— This studied investigated the usage of virtual laboratory (VL) on grade 11 students' learning outcomes of fluid statics and dynamics toward physics. The research used quasi experiment with the design of static group comparison that aimed to determine; 1) the magnitude of students' learning outcomes by VL; 2) the amount of students' learning outcomes who are taught without VL; 3) significant difference to the students' learning outcomes who are taught by VL and without using VL. The population in this study were all students of grade 11 of SMAN 21 Makassar in 2015/2016 Academic Year. The sample was selected randomly which selected as an experimental class was 11 science A and 11 science B as the control class. The instrument used was a physics learning outcome test for fluid statics and dynamics materials in multiple-choice form. The calculation of descriptive analysis and inferential result showed that the students' learning outcomes are taught with VL is higher than the learners who are taught without using VL. The results of the normality test obtained a significance value is 1.66 with a significance level of 5% for the experimental class and 3.28 for the control class with values 1.66 > 0.05 and 3.28 > 0.05. It appears that the experimental class and the control class are normally distributed. Homogeneity test of two variances produces significance value of the count is 1.14 and significance value of the table is 1.74. This is written 1.14 > 1.74, then the conclusion is the experimental class and the control class students come from a homogeneous population. Then hypothesis testing has been carried out using the two-party t-test where the significance value obtained from the count is 2.10 and the significance value of the table is 2.03. Because 2.03 < 2.10, H_0 is rejected and H_1 is accepted. In other meaning there are significant differences in students' learning outcomes toward physics that taught by VL and without taught by VL.

Keywords: virtual laboratory (VL), students' learning outcomes, physics, fluid Statics and dynamics

I. Introduction

Natural phenomena, the formation of the universe, and all interactions within it which cover a wide range ranging from sub-atomic particles forming matter to the behavior of the universe as a cosmic union called physics. Physics in general is a subject that students fear. The reason is students have difficulty imagining abstract concepts to be understood. Therefore, there are many students who answer physics questions relying on memorizing formulas without knowing where the formula formed. The fact is learning physics makes students gain experience in designing critical abilities. Physics learning can also develop the ability to do scientific methods for solve problems in real life. Laboratory activities (experimenting) can train students' scientific attitudes in understanding the concept of the lesson [12].

The abstract concept in physics should be transformed and able to experience by the five senses. So that the participants can understand the physics concept in a real experience. In achieving that process, physics lessons often done sided with physics practicum. But not all can be understood by practicum activities. The limitations in facilities, infrastructure and time allocation in the learning process cannot be a solution. Two very important elements in the learning process in the classroom, namely the model or strategy and learning media. Therefore, it is necessary to taken steps to make the materials transfer more communicative in develop the teaching methods and the usage of instructional media [1]. The use of instructional media in the learning process can generate new passions and interests, raise motivation and stimulation of learning activities, and even bring psychological effects on students [11].

The media selection criteria are based on the concept that learning media are part of the overall instructional system [2]. Media selection is carried out when the educator will make teaching aids to facilitate students in teaching and learning activities, the more technological sciences develop, the more there will be media and the media will expand there. Therefore, the selection of media must be in accordance with predetermined principles such as having goals that are in accordance with the nature and characteristics of the media to be used [7].

According the two statements above, it could be that Good media is multimedia that the learners are more active in their learning and explains the content in a different way than traditional methods. Multimedia regarded as an interesting learning media, based on effort touches many senses, sight, hearing, and touch. Instructional media over the development period can be classified in four groups: printing technology, audio-visual technology, computer-based technology, and technology combined.

In this study the media used were virtual laboratory. One example is the Physics Education Technology (PhET) simulation. PhET is a simulation made by the University of Colorado that contains simulations of learning physics, biology, and chemistry for the benefit of teaching in class or individual learning. PhET simulations emphasize the relationship between real life phenomena and the underlying science, support interactive and constructivist approaches, provide feedback, and provide a creative workplace [6]. "Computer programs enable complex system simulations, receive input from students, calculate results and inform students through communication media about changes made" [8].

"The advantages of the virtual laboratory or an interactive computer simulation can show abstract concepts that cannot be displayed on a real laboratory equipment (real equipment) [15]." The use of virtual laboratory can overcome some of the problems encountered related to inadequate laboratory equipment and make a positive contribution in achieving learning objectives [4].

Observations have been conducted at SMAN 21 Makassar on physics learning resulted that teaching at the school is still conventional and laboratory facilities are rarely used for experiments. One of the factors that influence the success of experimental activities is resources that include materials and equipment, space and facilities for laboratory assistant, and technicians. The availability of these resources can support the implementation of the experimental activities.

The categorization of scores of learning outcomes in the interval score of 81% - 100% is very high, the interval score of 61% - 80% is high, interval score 41% - 60% is medium, interval score of 21% - 40% is low, and the interval score of 21% - 40% is very low [1]. Students' learning outcomes are intrinsically behavioural changes that include fields cognitive, affective, and psychomotor. The learning result is relative, meaning the provision of learning outcomes cannot guarantee one hundred percent that if the result of high learning then a clever student and vice versa. Because the reality in the field shows that there are still many students who study results is high but still stupid and vice versa. This is due to the learning outcomes are influenced by many factors: the material being studied, environmental, facilities / infrastructure, students, and teachers [14].

According to the description above, the researcher draws the conclusion that student learning outcomes towards physics is the result achieved by student which there are behavioral changes that occur in the cognitive, affective, and psychomotor fields to achieve the learning objectives of physics material.

It is known from the observation result of students who obtained very high score intervals amounting to 4 of 38, high score intervals amounting to 14 of 38, low score intervals totaling 18 of 38, and very low score intervals totaling 2 of 38. In observation, it was also found that students rarely conducted experiments because of limited time. However, it is known that the characteristics of students at school are very enthusiastic about new things and happy by trying something new.

Then in connection with the above, one alternative that can be used to overcome the problem of students' learning outcomes towards physics are applying the learning by using virtual laboratory in order to provide convenience to students to better understand the material provided in the learning process.

Based on these descriptions, the researcher is encouraged to conduct research with the title, "The Usage of Virtual Laboratory on Grade 11 Students' Learning Outcomes toward Physics". This research aimed to determine; 1) the magnitude of students' learning outcomes toward physics that taught using virtual laboratory; 2) the amount of students' learning outcomes toward physics that taught without using virtual laboratory; 3) significant difference on grade 11 students' learning outcomes toward physics that taught using virtual laboratory and without using virtual laboratory.

II. METHOD

A. Type and Research Data

This research is a quasi-experiments study. The research design used is static - group comparison. The research design is as follows:

X	O_1
- - - - - - - - - - -	
	O_2

Notes:

X : Treatment provided in the form of learning using a virtual laboratory.

O_1: Measurement of the dependent variable after the treatment phase ends.

O_2: Measurement of the dependent variable after the treatment phase ends.

---: Experimental and control classes are not obtained through random.

[3]

In this study there are two variables, namely a virtual laboratory as an independent variable and students' learning outcomes towards physics as a dependent variable. The virtual laboratory is a set of tools consisting of PHET for the physics of fluid statics and dynamics materials in order to channel messages easily and to achieve the objectives of learning physics. Physics learning outcomes are measures that further indicate the learning objectives obtained by students through the use of virtual laboratory.

B. Location Research

The research location is at SMAN 21 Makassar which was conducted in the even semester for two months of the 2015/2016 academic year.

C. Population and Sample Data

The population in this study were all grade 11 students of SMAN 21 Makassar in the even semester of the 2015/2016 academic year. The sample selection in this study was not used random, but determined directly by the physics subject teacher. This is done so as not to interfere with the learning process because it forms a new group outside the existing class (John Creswell, 2015). By using the above technique, two classes of samples will be obtained in the population, namely class 11 science A as the experimental group and class 11 science B as the control group. In the experimental group the virtual laboratory will be used while the control group will not be applied in the virtual laboratory.

D. Data Analysis Techniques

The data analysis technique of this research is descriptive and inferential analysis. This analysis is intended to describe the students' learning outcomes toward physics obtained by students after being taught using a virtual laboratory. This is intended to determine the number of samples, the highest score (maximum), the lowest score (minimum), the average score, the standard deviation. Average scores are obtained from the equation:

$$\bar{x} = \frac{\sum x_i}{N} \quad (1)$$

Where the data are arranged in the frequency distribution lists:

$\bar{x}$: Average score
x_i : Interval score
N : Number of samples

[13]

Variance is obtained from the equation:

$$S^2 = \frac{n\sum f_i x_i^2 - (\sum f_i x_i)^2}{n(n-1)} \quad (2)$$

Standard deviation is obtained from the equation:

$$S = \sqrt{\frac{n\sum f_i x_i^2 - (\sum f_i x_i)^2}{n(n-1)}} \quad (3)$$

Notes:
S : Standard deviation value
x_i : Interval class
f_i : Frequency corresponding to the number of samples

[13]

Descriptive categories of student physics learning outcomes based on the criteria stated by Riduwan. If the categorization in the table is adjusted to the score of learning outcomes in this study, then obtained:

TABLE I. FREQUENCY DISTRIBUTION OF STUDENTS' LEARNING OUTCOME CATEGORIES ON EXPERIMENT AND CONTROL CLASS.

Interval Score (xi)	Interval Score (%)	Learning Outcome Categories	Experiment		Control	
			Fi	*%*	*fi*	*%*
15 – 18	81 – 100	Very high	9	24	6	16
11 – 14	61 – 80	High	20	53	17	45
8 – 10	41 – 60	Average	9	24	4	37
4 – 7	21 – 40	Low	0	0	1	3
0 – 3	0 – 20	Very low	0	0	0	0

(Riduwan, 2011)

For normality testing in inferential analysis the chi-square formula is used as follows:

$$\chi^2_{count} = \sum_{i=1}^{k} \frac{(O_i - E_i)^2}{E_i} \quad (4)$$

Notes:
χ^2_{hitung} : Chi-square value calculated
O_i : Frequency of observation
E_i : Frequency of expected result
k : Number of interval class

Criteria:
Data from population are normally distributed if χ^2_{count} smaller thani χ^2_{table} which χ^2_{count} obtained from the list χ^2 with *df* = (k-1) at the significance level α = 0.05.

[10]

Hypothesis testing uses a two-party test. For homogeneous variance the t test is used as follows:

$$t_{count} = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\left(\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}\right)}} \quad (5)$$

which,

$$S^2 = \frac{n\sum_{x=1}^{n} x_i^2 - (\sum_{x=1}^{n} x_i)^2}{n(n-1)} \quad (6)$$

Note :
$\bar{x}_1$: The average score of the experimental group
$\bar{x}_2$: The average score of the control group
S_1 : Standard deviation of the experimental group
S_2 : Standard deviation of the control group
n_2 : Number of experimental group sample
n_2 : Number of control group sample
$\sum x$: Summerize of sample

[13]

The hypotheses tested in this study are:

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

Note:

$H_0 : \mu_1 = \mu_2$: There is no significant difference in the students' learning outcomes toward physics that taught with virtual laboratory with students taught without virtual laboratory.

$H_1 : \mu_1 \neq \mu_2$: There is significant difference in the students' learning outcomes toward physics that taught with virtual laboratory with students taught without virtual laboratory.

μ_1 : The average score of students' learning outcomes toward physics that taught using virtual laboratory.

μ_2 : T

The testing criteria are for two-party test: $H_0 : \mu = \mu_0$ and $H_1 : \mu \neq \mu_0$, the conclusion criteria are H_0 accepted if $t - table > t - count$, and vice versa H_1 is accepted if $t - table < t - count$.

[13]

III. RESULTS AND DISCUSSION

A. *Descriptive Analysis*

TABLE II. DESCRIPTIVE ANALYSIS OF STUDENTS' LEARNING OUTCOMES

Statistics	Students' Learning Outcomes	
	Experiment	*Control*
Total sample	38	38
The highest score	17	15
The lowest score	9	6
Average score	12.47	11.32
Deviation standard	2.31	2.47
Variance	5.39	6.11
Range Score	18	18

(Source: processed primary data, 2019)

Based on table 2, it is obtained that the students' learning outcomes of experimental class who were taught using virtual laboratory shows that the highest score achieved is 17, the lowest score is 9. While the average score achieved is 12.47. For the learning outcomes of control class students who were not taught using virtual laboratories showed that the highest score achieved was 15, the lowest score was 6, while the average score achieved was 11.32.

Based on Table 2, it can be seen that the standard deviation for the experimental class 2.31 and for the control class 2.47. Standard deviation is a reflection of the average deviation of the average score data. Standard deviations can illustrate how far the data varies. The overall number in the control class is 38 people, while the total number of students in the experimental class is 38 people.

Scores of students in the experimental class and the control class are categorized based on the categorization of learning outcomes, then a frequency distribution table can be made based on the categories of students' learning outcomes in the experimental class and the control class as follows:

TABLE III. FREQUENCY DISTRIBUTION OF STUDENTS' LEARNING EXPERIMENT CLASS

Descriptive Analysis						
Interval Score	f_i	x_i	x_i^2	$f_i . x_i$	$f_i . x_i^2$	%
9 – 10	9	9	89	85	802	24
11 – 12	9	11	128	102	115	24
13 – 14	11	13	179	147	1963	29
15 – 16	8	15	236	123	1891	21
17 – 18	1	17	289	17	289	3
Total	38	67	921	474	6101	100

(Source: processed primary data, 2019)

Based on table 3, for the learning outcomes of experimental class students taught by using a virtual laboratory, it shows that most are located at intervals of 13 – 14 with a frequency of 11 students. While at least lies in the interval 17 – 18 with a frequency of 1 student but is at the highest interval score.

TABLE IV. FREQUENCY DISTRIBUTION OF STUDENTS' LEARNING OUTCOMES ON CONTROL CLASS

Descriptive Analysis						
Score Intervals	f_i	x_i	x_i^2	$f_i . x_i$	$f_i . x_i^2$	%
5 – 6	1	6	36	6	36	3
7 – 8	3	8	64	24	192	8
9 – 10	11	9	84	101	927	29
11 – 12	8	11	129	91	1035	21
13 – 14	9	13	172	118	1547	24
15 – 18	6	15	225	90	1350	16
Total	38	63	711	430	5087	100

(Source: processed primary data, 2019)

Based on table 4, for the learning outcomes of control class students who are not taught using virtual laboratory show that the most data is located at intervals of 9 – 10 with a frequency of 11 students. While the data is at least located at intervals of 5 – 6 with a frequency of 1 student.

The total score of students' learning outcomes for each indicator can be seen in the picture below:

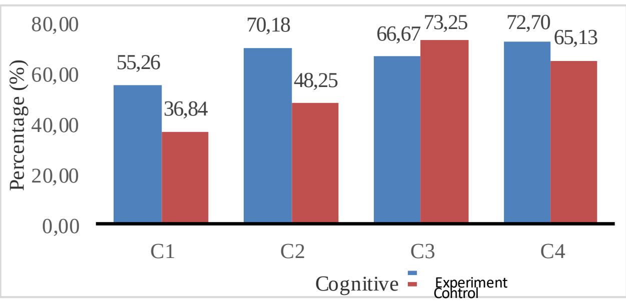

Fig. 1. Percentage of Cognitive Indicators

From figure 1, it can be seen that the experimental class and control indicator with the lowest score is C1 (remember) while the highest score in the experimental class is C4 (analyze) and the control class is C3 (apply).

B. Normality Test

The normality test results of the science process test scores of the experimental class and control class students using chi-square can be seen in table 5.

TABLE V. NORMALITY TEST RESULT OF STUDENTS' LEARNING OUTCOMES ON EXPERIMENT AND CONTROL CLASS

Score	χ^2 (count)	Α	df	χ^2 (table)
Experiment	1.66	0.05	4	9.48
Control	3.28	0.05	5	11.07

(Source: processed primary data, 2019)

In table 5, it can be seen that the calculation result for the experimental class taught using virtual laboratory obtained χ^2_{count} = 1.66. For α = 0.05 and dk = k-1 = 5-1 = 4, it got $\chi^2_{table} = \chi^2_{(0.05)(37/37)}$ = 9.48. Thus, $\chi^2_{count} < \chi^2_{table}$ (1.66 < 9.48), which means the score os students' learning outcomes comes from a normally distributed population. Likewise, the control class that was not taught using a virtual laboratory was obtained χ^2_{count} = 3.28. For α = 0.05 and dk = k-1 = 6-1 = 5, it obtained $\chi^2_{table} = \chi^2_{(0.05)(37/37)}$ = 11.07. Thus, $\chi^2_{count} < \chi^2_{table}$ (3.28 < 11.07) which means the students' learning outcomes come from normally distributed population.

C. Homogeneity Test

Based on the results of normality testing, it turns out the data obtained from populations that are normally distributed, then proceed with the homogeneity test of population variance. For testing the homogeneity of variance is the learning outcome data for experimental class taught using virtual laboratory and control class not taught using virtual laboratory. Test criteria if $F_{count} < F_{table}$ then the data are homogeneous. Conversely, if $F_{count} > F_{table}$ then the data is not homogeneous, with df = (k – 1) in the significant level α = 0.05.

Based on the analysis with α = 0.05, the value of F_{count} and F_{table} was obtained for students' learning outcomes, F_{count} = 1.14 with F_{table} = 1.74. Because $F_{count} < F_{table}$ this shows that data in this study are homogeneous.

D. Hypothesis Test

The hypotheses tested in this study are:

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

Note :

$H_0 : \mu_1 = \mu_2$: There is no significant difference in the students' learning outcomes toward physics that taught with virtual laboratory with students taught without virtual laboratory.

$H_1 : \mu_1 \neq \mu_2$: There is significant difference in the students' learning outcomes toward physics that taught with virtual laboratory with students taught without virtual laboratory.

μ_1 : The average score of students' learning outcomes toward physics that taught using virtual laboratory.

μ_2 : The average score of students' learning outcomes toward physics that taught without virtual laboratory.

The testing criteria are for two-party test: $H_0 : \mu = \mu_0$ and $H_1 : \mu \neq \mu_0$, the conclusion criteria are H_0 accepted if $t - table > t - count$, and vice versa H_1 is accepted if $t - table < t - count$. And t-table = 2.03.

Hypothesis testing of this study used a two-party test with the t-test so that the t_{count} value obtained for the virtual laboratory was 2.10 while t_{table} is 2.03. Because $2.03 < 2.10$, H_1 is accepted and H_0 is rejected. Thus, it can be concluded that there is a significant difference between the students' learning outcomes toward physics that taught using virtual laboratory and taught without using virtual laboratory which is significant level $\alpha = 0.05$.

Student physics learning outcomes are provided after applying the use of virtual laboratory in the multiple-choice form with total 18 items. Based on the results of the descriptive analysis gives overview about the highest score, lowest score, average score, variance and standard deviation of the experimental and the control class. The average score obtained is 12.47 for the experimental class and 11.32 for the control class which the ideal score is 18. Then the standard deviation for each class is 2.31 and 2.47. When viewed from the minimum and maximum score obtained by students, experimental class have 9 for minimum score and 17 for maximum score, while the control class have 6 for minimum score and 15 for maximum score. This shows that based on the physics learning outcome categories in Table I, the average score of the physics learning outcomes are in the high category while the minimum score obtained by students is in the medium category for the experimental class and low for the control class. The maximum score is in the very high category for each class. 9 of the 38 students are in the very high score interval, 20 of the 38 students are in the high score interval, 9 of the 38 students are in the medium score interval, and there are no students in the low or very low score interval for the experimental class. Whereas for the control class, 6 out of 38 students are in the very high score interval, 17 out of 38 are in the high score interval, 4 out of 38 students are in the medium score interval, and 1 out of 38 students is in the low score interval.

Assessment of learning outcomes in this study only focused on the cognitive domain in Anderson's Taxonomy. Because in the cognitive domain, student learning outcomes is easier to know and also difficult to assess when learning is short time. The cognitive domain is focused on knowledge, understanding, application, and analysis.

Based on the results of the study, it can be concluded that learning using virtual laboratory is learning that can make students actively participate in learning by doing and trying out practicums themselves in the form of simulations. This is in accordance that learning media is a set of tools that help in distributing messages easily in order to achieve the desired goals in learning [9]. The obstacle found by researcher is the lack of knowledge of students using the Microsoft Excel program which requires researcher to guide students in their use. From the result of this study it can be seen differences in the learning outcomes of students taught using virtual laboratory and without virtual laboratory. In general, physics learning outcomes of students are in the high category for experimental class.

IV. CONCLUSION

Based on the results and discussion, it can be concluded that; 1) The score of students' learning outcomes on grade 11 of SMAN 21 Makassar in 2015/2016 Academic Year taught using virtual laboratory is 12.47; 2) the score of students' learning outcomes on grade 11 of SMAN 21 Makassar in 2015/2016 Academic Year that is taught without using virtual laboratory is 11.32; 3) There are significant differences of students' learning outcomes who are taught using virtual laboratory with those taught without using virtual laboratory on grade 11 of SMAN 21 Makassar in 2015/2016 Academic Year.

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