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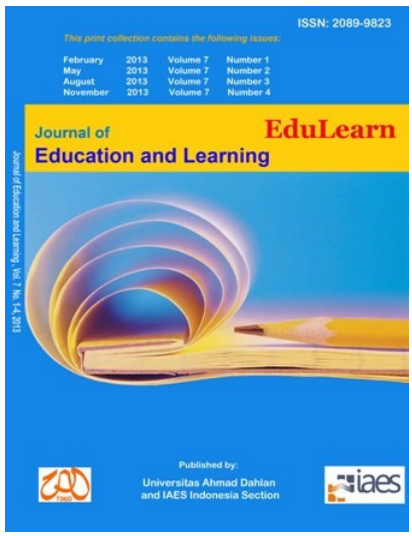

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The effect of virtual reality laboratory on conceptual understanding in electrolytes and non-electrolytes

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ABSTRACT

This study aims to determine the effect of the use of learning media Virtual Reality Laboratory (VR-Lab) on the conceptual understanding of Senior high school students on the concept of electrolytes and non-electrolytes. The learning media used were developed using models adapted from the ADDIE model, while the type of research as a whole uses this type of research, namely Quasy experiment with posttest only design. The instrument used in this study was a multiple choice question of 40 items. This research was conducted using 84 students consisting of the control class, experiment I, and experiment II. The analysis technique used one-way ANOVA. The results obtained in this study were that between the control class and experiment I class there were no significant differences with a mean of 44.91 and 45.67. Whereas for the experimental II class had a significant difference with the other two classes with an average of 68.66.

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1. INTRODUCTION

Chemistry is one part of science so it becomes an important thing to know. Chemistry is known to have abstract characteristics. Because there are some materials that cannot be seen and observed directly. In chemistry there are three main levels that must be mastered namely sub-microscopic, macroscopic and symbolic [1]. One way to solve this problem is by way of students having to understand the concept of chemistry first. Understanding the concepts of students is very important because basically chemistry is a material based on concepts [2]. Students are categorized as understanding if they are able to transfer and connect macroscopic, sub-mochroscopic and symbolic phenomena. The key point in the solution is the ability to represent chemical phenomena at sub-microscopic levels [3, 4].

Improving the understanding of students' chemical concepts can be done by providing visual aids so the concepts can be understood by means of the concepts explained orally and with the help of teaching aids to provide a real picture and can visualize the concepts explained [5]. This is in accordance with the learning developed in the 2013 curriculum (Indonesian curriculum) which is based on a scientific approach that has steps which are observing, asking, collecting data, reasoning, and communicating. These steps are known as 5M. Learning with practical assistance in chemistry is done because most of the concepts and theories of chemistry presented in the curriculum are assisted by laboratory testing as proof or verification. The importance of using a laboratory can help students to adapt in solving problems found in science [6]. The learning process aims to make abstract chemical concepts concrete so that students can understand the concept of chemistry by itself in accordance with the experience obtained by himself.

The laboratory is a way to understand the concepts obtained from practicum used to solve problems related to previously owned concepts that are not understood by students. Understanding of concepts is one of the learning outcomes that students will receive after the teaching process which is on cognitive shutter that has the domain of thinking, knowing, and solving problems. However, not all schools have adequate laboratories so a media that can overcome this is needed. Technological advancements provide solutions for improving the quality of learning. Related to this, a virtual laboratory was developed so that technology-based learning as a solution to simulate experimental activities in the laboratory. Virtual laboratory is a media that helps students by providing an interactive experience in observing and manipulating objects, the system produced, data and phenomena to fulfill the learning taught [7]. Interactive diving is supported by an interactive environment that is presented in a virtual laboratory in the form of a playground for experiments in the virtual world. The program is a domain-based simulation program in the form of an experimental unit with data files and tools operating on objects in a virtual environment [8].

Virtual Laboratory is a supporting factor to enrich experience and motivate students to conduct experiments interactively and develop experimental skills activities. Thus, virtual laboratories can be called as a series of programs that can visualize abstract or complex phenomena carried out in real laboratories, so as to increase learning activities in an effort to develop skills needed in problem solving [9]. The use of virtual laboratories has the advantage of being able to do it anywhere and anytime and students can do experiments safely if the actual experiments are dangerous. The use of this laboratory is also cheaper compared to real laboratory experiments because it requires relatively expensive tools and materials [10, 11]. Previous research has shown that laboratories improve independence and understanding the concepts of learners in learning [12] and virtual laboratories are more effective to use than classical teaching [13]. In addition, virtual laboratories can be used in conceptual learning [14] and learning innovations [15].

2. RESEARCH METHOD

This research used the experimental method (Quasy experiment) with post-test only design [16]. The media used was developed using a development model adopted from the ADDIE [17] development model which stands for Analysis, Design, Development, Implementation, and Evaluation. The aim of which is to determine the effect of VR-Lab media on students' conceptual understanding in the concepts of electrolytes and non-electrolytes in chemistry. Products developed in the form of software with Android operating system (.apk) are run using an Android smartphone and Virtual Reality glasses (VR-Box). The trial design can be seen in Table 1.

Table 1. Posstest only design

Class	Treatment	Posttest
Contol	A	O
Experiment I (Media)	B	O
Experiment II (Mix)	AB	O

Notes:
A :Regular practice
B :Practicum using VR-Lab media
AB :Regular practice and VR-Lab media
O :Instruments test to measure students' Conceptual understanding

The research data was collected using conceptual understanding sheets. The question sheet for understanding chemical concepts in electrolytes and nonelectrolytes used a type of multiple choice question with 40 questions and each had 5 choice questions. Before testing the problem, it was first carried out empirical validity of the conceptual understanding sheet using 3 schools in Barru district (South Sulawesi-Indonesia). The first school used 3 different classes from the school which was the subject of the study, namely SMA Negeri 1 Barru, the second school used used 4 classes namely SMA Negeri 3 Barru, and the third school used 2 classes namely SMA Negeri 6 Barru. The number of subjects in this empirical validity was 250 students. Validity and reliability and item fit data will be measured using the QUEST program. While for the research class using 3 classes consisting of control classes as many as 29 students, media classes 27 students, and mix classes as many as 28 students. Testing the hypothesis in the study using one-way ANOVA statistical analysis techniques using the SPSS 22 program.

3. RESULTS AND ANALYSIS

3.1. Media development

The VR-Lab developed was a VR-Lab that was different from previous VR-Labs which only used computers or mobile phones. As in previous studied [12, 18] and previous virtual laboratory development. The VR-Lab developed was a virtual reality laboratory that applies 3D interactions using VR-Box and controller as supporting applications that exist in Android smartphones that come in .apk. This VR-Lab was an application developed using Blender and Unity software. Blender served to create a 3D laboratory room and 3D objects in a virtual laboratory. Whereas, Unity had a function as a developer application in the 3D interaction process in VR-Lab so that this application could be combined with a VR-Box. The VR-Lab developed simulated electrolyte and non-electrolyte practicum-based practicum in a virtual reality laboratory. The appearance of the application developed can be seen in Figure 1, Figure 2, and Figure 3.

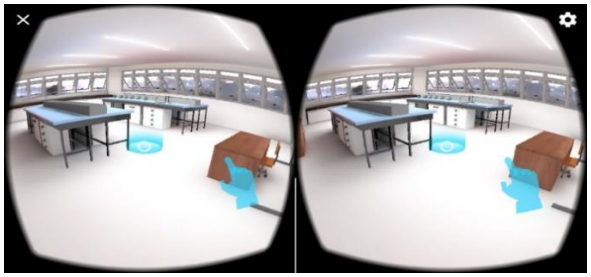

Figure 1. VR-Lab display

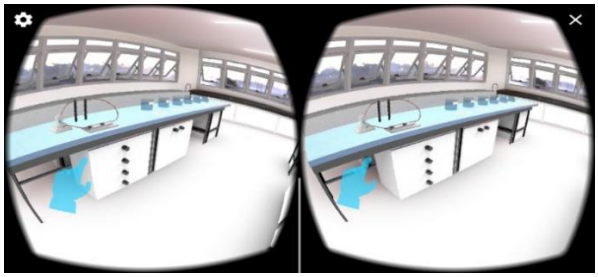

Figure 2. Simulation lab table in VR-Lab

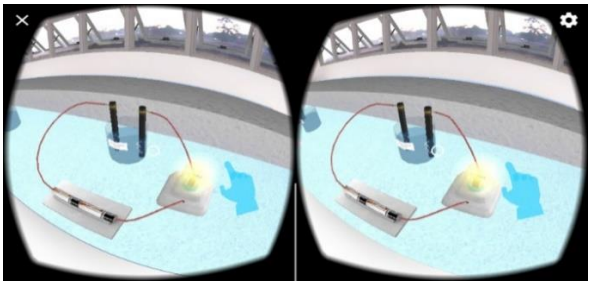

Figure 3. Practicum using VR-Lab

3.2. Empirical validation of questions instrument

Instruments about conceptual understanding used in the assessment were first carried out expert validation before used. The results of expert validation on the problem of understanding the concept were declared feasible to use with a revised note first. The next step was the empirical validation using 250 students from 3 schools. The results of these tests carried out instrument reliability and item fit using the QUEST program. The reliability of the question shown that the concept of conceptualization had a reliability value of 0.96. Reliability results can be seen in Figure 4.

```
Summary of item Estimates
=========================

Mean                    .00
SD                      .84
SD (adjusted)           .83
Reliability of estimate .96
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Figure 4. Results of reliability with the QUEST program

Whereas The results of the analysis show that fit items from the understanding of concepts could be used for all the items, namely 40 items. Item fit can be seen in Figure 5

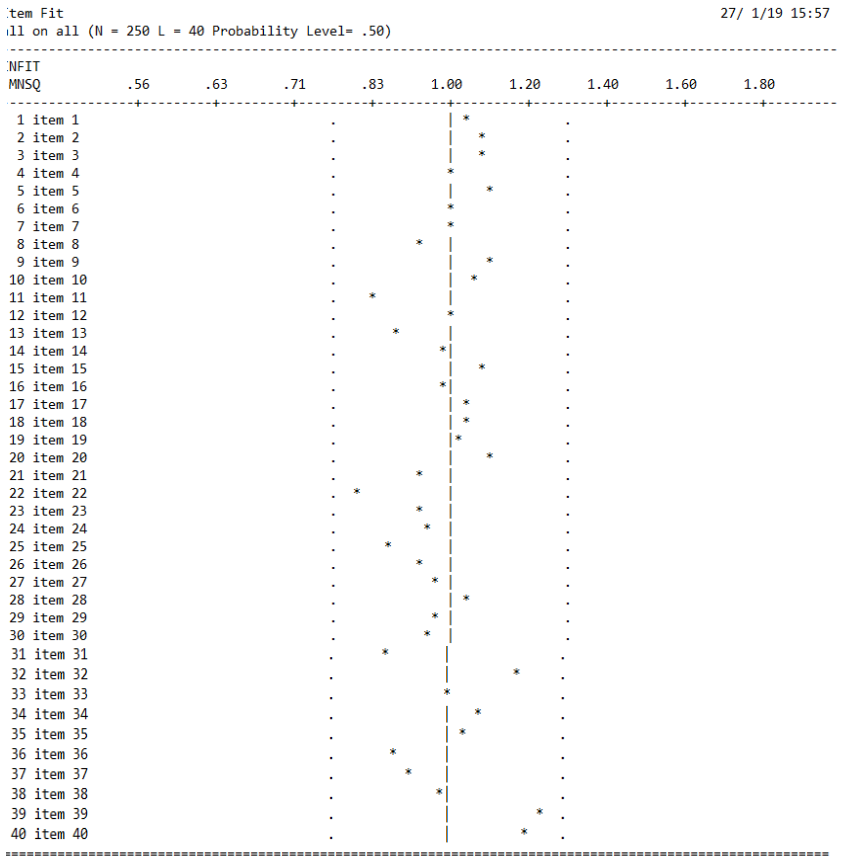

Figure 5. Analysis of Item fit with the QUEST program

3.3. The implementation of VR-Lab Media

The next process was the implementation of VR-Lab media that could be used as a medium in data collection in research. This study used 3 different classes taken from grade in SMA Negeri 1 Barru. The first class was a class using ordinary practicum or without using VR-Lab media in practicum (control class), the second class was experimental class I which was the class that used VR-Lab media in the practical process (media class), and the third class was experimental class II namely classes that used ordinary laboratoriy that were combined with the used of VR-Lab media in the practical process (mix class). The learning process using or without VR-Lab can be seen in Figure 6.

(a) **(b)** **(c)**

Figure 6. Learning process, (a) Control Class (ordinary practicum), (b) Experiment Class I (media practicum), and (c) Experiment Class II (ordinary practicum and media practicum)

The results of the implementation process were carried out in the classroom by taking data on students' conceptual understanding by carrying out the posttest process on 3 research classes using instruments that had been approved empirically. Results of the average posttest value Understanding the concepts of students from three classes can be seen in Figure 7.

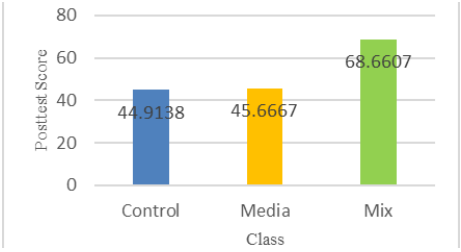

Figure 7. Difference in average of conceptual understanding

The number of each sample in 3 classes, the comparison of the average, standard deviation, minimum and maximum values of each class can be seen in Table 2.

Table 2. The results of conceptual understanding of students

No	Kelas	N	Mean	Std. Deviation	Minimum	Maximum
1	Control	29	44.9138	11.52410	22.50	65.00
2	Eksperiment I (Media)	27	45.6667	12.58739	25.00	70.50
3	Eksperiment II (Mix)	28	68.6607	10.52955	47.50	92.50
	Total	84	53.0714	15.92398	22.50	92.50

3.4 Statistical Tests

Statistical tests were then conducted to determine the effect of VR-Lab by conceptual understanding students' concepts. Test statistic used by one-way ANOVA statistical test using the SPSS 22 program. Before the ANOVA test, the normality prerequisite test was carried out using Shapiro-Wilk. The results of this test can be seen in Table 3.

Table 3. Normality test results

No.	Class	Shapiro-Wilk		
		Statistic	df	Sig.
1	Control	.947	29	.154
2	Eksperiment I (Media)	.961	27	.399
3	Eksperiment II (Mix)	.983	28	.913

The analysis results shown that the Sig. > 0.05, it could be concluded that the research data was normally distributed so that further analysis could be carried out, namely analysis of ANOVA.
Another prerequisite test besides the normality test is the homogeneity test. The homogeneity test used in the analysis was Levene Statistics. The test results can be seen in Table 4.

Table 4. Homogeneity test results

Levene Statistic	df1	df2	Sig.
0.559	2	81	0.574

Based on the results of the Levene Statistics value of 0.559 with a significance (sig.) of 0.574. Because of the sig value. 0.574> 0.05, it could be concluded that the variants of the three classes tested/compared were the same or homogeneous. Furthermore, ANOVA analysis to find out whether the three class groups had differences in understanding significant concepts or not. ANOVA test results can be seen in Table 5.

Table 5. Results of one-way ANOVA analysis

No.		Sum of Squares	df	Mean Square	F	Sig.
1	Between Groups	10215.010	2	5107.505	38.195	.000
2	Within Groups	10831.561	81	133.723		
	Total	21046.571	83			

Based on the table it can be seen that the sig value. that is 0.000 < 0.05 so it can be concluded that the average of the three groups of classes is "DIFFERENT" significantly. Further analysis of ANOVA was a Post-Hoc test using the Bonferroni test with the aim of conducting multiple comparison tests to determine whether the three averages or more differed significantly in the number of analysis variants. The results of the Post-Hoc test analysis can be seen in Table 6.

Table 6. Post-hoc test results with the Bonferroni test

(I) Class	(J) Class	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Control	Media	-.75287	3.09255	1.000	-8.3133	6.8075
	Mix	-23.74692*	3.06381	.000	-31.2371	-16.2568
Media	Control	.75287	3.09255	1.000	-6.8075	8.3133
	Mix	-22.99405*	3.11906	.000	-30.6193	-15.3688
Mix	Control	23.74692*	3.06381	.000	16.2568	31.2371
	Media	22.99405*	3.11906	.000	15.3688	30.6193

In the table it was known that the average difference for the control class and media was -0.75287 (difference from descriptive output). The average difference ranges from -8.3133 (lower bound) to 6.8075 (upper bound) at a 95% confidence level. There were differences or not seen from the sig value. Based on these data it was known that the value of sig 1.000> 0.05, it could be concluded that between the control class and the media was the same or no significant difference. Whereas, the class that had a significant difference was between the control class and the mix class, and the media class and mix class, namely sig 0.000 <0.05 which proved that there were significant differences.

The use of technology-based learning media is highly highlighted in the 21st century learning style that is centered on the advancement of information technology (IT). IT-based learning media have been developed so that it can be used as a support in learning so that it can improve student learning achievement [19], learning independence and understanding of students' concepts [12]. IT-based learning media can be applied as an alternative in carrying out practicum, Practicum that can be applied is a laboratory-based virtual lab. Virtual laboratories can be utilized in assisting learning processes specifically for chemistry that require experiments such as electrolyte and non-electrolyte materials. This learning media makes it easier for students to understand lessons that can be used as independent learning media that can be accessed inside and outside the classroom.

This is in accordance with the results of the research that has been conducted which proves that the experimental class II has a higher understanding value with other classes. Can be used to conclude the use of VR-Lab combined with conventional practicum is very good in improving students' understanding. Can be used as a simulation media / supplement before doing a real lab. The application of VR-Lab as a supplement media to help ordinary labors can answer the weaknesses of the VR-Lab itself which makes improving the ability of students because they do not do lab work such as pouring solutions, measuring properly using actual practicum tools [20]. Learning the application of learning as in experimental class II is very effective.

In addition to supplements, VR-Lab can be used as a substitute for ordinary practicum as in the results of research that prove that the VR-Lab class and practicum VR-Lab practicum class are approved by practicum can be used to assist experiments conducted so that it is carried out safely. The use of VR-Lab can also be done by practicum which will be carried out using relatively expensive tools and materials [10]. VR-Lab also has the advantage of being able to work anywhere and anytime and do not need tools and chemicals. VR-Lab can also change components such as particle movement, particles, interactions between particles, changes in material structure due to the influence of the environment or reading data in the form of numbers and changes directly. Learning media like this make it easier for students to understand lessons that can be used as independent learning media that can be accessed inside and outside the classroom. This learning media can be integrated with learning methods that are complemented by technological advances through online learning systems and traditional methods [21].

This VR-Lab can be introduced as a system that can be used to support systems running conventional laboratories. VR-Lab provides opportunities for students to experiment with or without access to the internet so students do not need to be present to discuss experiments in the laboratory. This kind of

learning is effective because students can learn on their own actively without an instructor or assistant and unlike the current system. The importance of using laboratories can help students to support laboratory activities that have the potential as learning media that contribute to student learning outcomes that are important from science learning [22].

4. CONCLUSION

The results of the VR-Lab implementation are carried out using 3 different classes, namely the control class (ordinary practicum), experimental class I (VR-Lab media class) and experimental class II (ordinary practicum and VR-Lab media) in terms of understanding the concept of students giving results, namely from the class with VR-Lab as a supplement (experiment II) has a significant difference with the class using a laboratory without media (control class). Meanwhile, for classes that use VR-Lab as an experiment (experiment I) does not has a significant difference. So that it can be said that media practicum can be used as a substitute and complement of ordinary practice.

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