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The Impact of Virtual Laboratory Integrated Into Hybrid Learning Use On Students' Achievement

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THE IMPACT OF VIRTUAL LABORATORY INTEGRATED INTO HYBRID LEARNING USE ON STUDENTS' ACHIEVEMENT

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Abstract

The virtual laboratory for electrochemistry materials has been developed. The characteristic of this virtual chemistry laboratory associated with the effect on students' achievement was analysed. Thus this type of research was research and development (R&D) by using ADDIE development model. In the implementation, phase of product was quasi experimental method with post-test only design. Classes used for this study were 3 classes, first class using traditional laboratory, second class using only virtual laboratory, and the third class using traditional laboratory and virtual laboratory as a supplement. All three classes were performed by the same teacher and the learning time. The instrument used to see the effect of virtual laboratory was a test instrument. While the instrument used to assess the quality of the media was a questionnaire assessment. The results of this study were a developed virtual laboratory which can be operated via web on smartphones and computers. In addition, the results of the assessment by the chemistry teachers stated that the virtual laboratory was in good quality and in classroom studies, the third and first classes showed significant differences. In the future research virtual laboratory as a supplement in other subject matters can be developed.

Keywords: *Virtual Laboratory, Hybrid Learning, Students' Achievement, Electrochemistry*



A. Introduction

The demand of Indonesian national curriculum are student-centered learning. This learning requires students to be active in finding the subject matter taught. It makes teachers always provide innovation and creativity. Teachers are required to minimize lecture method that are always used in learning in the previous curriculum. It helps students being not boring and more interested in following the learning process. Innovations by teachers vary, among them are group discussion, study literature, games based learning, and so forth. Such activities will be more meaningful for students in improving students' learning motivation (Liu & Chen, 2013).

Chemical learning is a science learning that can not be separated from practicum activities. Practicum activities become one of the student activities that can provide experience to the students. This activity is not separated from chemicals and chemical equipment that cost relatively expensive. In addition, much time is consumed when practicum activities are underway. Many teachers choose to abolish such laboratory activities. The survey results to some teachers suggest that they negated the practice because of the limitations of tools, materials and time available in schools. Teachers preferred to provide animated videos or practicum data only.

Technological developments become an important part of human life. The development of technology is always followed by the development of all components in life, one of them is that in the field of education. In education, technology becomes a part that can not be separated from teaching-learning process. Technological developments simplify the existing learning process, such as learning using projectors, animated videos, increasingly sophisticated computers, and so on. In a study before, many students relied on the existence of technology in academic needs (Al-Hariri & Al-Hattami, 2017). It became an important factor when designed the learning in classroom (Delen & Bulut, 2011). Along with the rapid development of technology, many researchers are developing a virtual laboratory. This scientific laboratory is a laboratory that can be used for practicum without the existence of tools and



materials in real. This practice can presumably be replaced through a smartphone screen, tablet or computer.

The virtual laboratory developed contained material presentations, virtual practicum, exercises, and media with an eye-catching look (Arista & Kuswanto, 2018). The development of virtual laboratory based on this technology should make students more engaged and interesting in learning activities. This technology-based learning utilizes electronic tools used daily by students. When a student is interested, he can absorb more the material the teacher teaches. Virtual laboratory was well received by students and can be used easily (Hidayat & Utomo, 2015). This laboratory can be operated in the classroom or outside the classroom, as long as there is an internet connection. Most of Yogyakarta Regions (One of the provinces in Indonesia) provide internet connection from various provider. Most senior high school kids can operate smartphones or computers well. There was more effective in science learning (Elsunni & Abdelwahed, 2014).

The educational effects of using virtual laboratory can be seen from several aspects, one of them as student achievement. Virtual laboratory are more effective and can improve learning outcomes in chemistry than traditional laboratory use (Alkan & Koçak, 2015). Virtual laboratory can organize a practicum performed by a student and enhance students' conceptions of thought material (Arista & Kuswanto, 2018; Hidayat & Utomo, 2015). This laboratory with free simulation can be motivate the students in learning process (Popovic & Naumovic, 2016). It can make improve the students' achievement (Bakar et al., 2013).

Hybrid-based learning is an issue that is being researched and developed by experts. This learning combines learning in the classroom or face-to-face with out-of-school or online-based learning. Hybrid learning is a learning mode that utilizes technology. This hybrid learning is not necessarily performed in the classroom with the classroom learning time, but it can be done outside the learning hours. Students might feel satisfied in doing hybrid learning and welcome positively in using this technology-based learning (Antonoglou, Charistos, & Sigalas, 2011; Toth, Morrow, &



Ludvico, 2009). This hybrid learning attracts students to follow further learning (Chigeza & Halberty, 2014).

Electrochemistry is one of the materials that require a lot of practice in the laboratory. According to the results of initial need analysis of the study, electrochemistry material became the second material that was chosen by many chemistry teachers to develop a virtual laboratory. Previous studies of using virtual laboratory in these subject resulted in the absence of significant differences between classes with virtual labs against classes using traditional laboratory (Hawkins & Phelps, 2013). In this study, the use of virtual laboratory was varied also to a virtual laboratory as a substitute and as a supplement.

Thus, three classes was performed with different treatment in using virtual laboratory, following real laboratory, virtual laboratory only instead of the real laboratory, and both of them but conducting at out of class as supplement for the latter. This development study to find out the characteristics of the virtual laboratory that developed and to observe this quality in terms of the assessment of experienced chemistry teachers. In addition, the study also observe the effect of virtual laboratory chemistry as a supplement and as a substitute that were compared to traditional laboratory. State the objectives of the work and provide an adequate background, avoiding a detailed literature survey or a summary of the results.

B. Method

Procedure of Development

This research and development was done according to ADDIE development design. This research begins with the analysis phase. At this stage, an open questionnaire was conducted to the chemistry teachers who had spent years teaching and analyzing the journals associated with the study. The second stage is the design stage, namely the stage of making a virtual chemistry laboratory storyboard that refers to the existing electrochemical theory. The third stage is the development stage, which is the development of virtual chemistry laboratory based on the web. The development of this virtual laboratory uses the construct program. Product



validation was done by lecturers of material experts, lecturers of media experts, chemistry teachers and students who were subjected to the use of this virtual laboratory. This media validation uses an open instrument of input. The validators involved are 2 material experts, 1 media expert, 1 chemistry teacher, and 3 high school students of grade 12.

Experimental Class

The effect of using virtual laboratory was analysed in the implementation phase in the classroom. It was done in one of the high schools in Yogyakarta (province of Indonesia). The samples taken were 3 classes of Grade 12th. The technique sampling was cluster random sampling. The school is consisting of 1 class of special intelligence and 6 regular classes. Of the six regular classes, 3 classes were chosen randomly. The six classes were homogeneous and normal value.

The Treatment of the first class was using traditional laboratory as usual and called the control class (CC) which was science 4. The second class was the first experimental class (EC-1) which was science 2. The treatment of This class was virtual laboratory instead of a traditional laboratory. The third class was the second experimental class (EC-2) which was science 5. The treatment of this class was both laboratory types, traditional laboratory and virtual laboratory as supplements. All three classes were treated in the same learning time and with the same teacher. There are 12 hours of lesson (each 45 minute learning hour) and twice online learning (each learning 60 minutes). Implementation in this class was quasi experimental method with post-test only design. The variables measured in the implementation of this class are students' achievement by comparing the average of the three classes.

Evaluation

At this stage, a virtual laboratory was assessed by several chemistry teachers in Yogyakarta. This was done to determine the quality of the developed virtual lab media. Teachers taken as assessors are 8 teachers. These eight teachers are seen from teaching experience, senior or junior, and their status in school.



Data Collection Instrument

The students' achievement test instrument consists of 30 multiple choices of questions and 3 description questions. This test instrument has passed the stage of expert validation and empirical validation.

The instrument used in the evaluation stage or assessment stage is an assessment questionnaire consisting of 20 items with 4 rating scales. This is a modification of the likert scale by eliminating the scale of doubt. This media assessment instrument was developed from 3 main aspects, namely material, learning, and technique (Kustandi & Sutjipto, 2011; Nesbit & Leacock, 2009; Oyelekan & Olokundare, 2009; Squires & Preece, 1996).

Data Analysis

The result of empirical validation of post test instrument were analyzed to see the reliability which must be not less than 0.70. The analyze difference of the scores for three classes was used ANOVA. It was employed to the one independent variable only of the data of students' achievement. While, the results of media quality were analyzed to see the quality. Converting assessment results to media quality refers to Table 1.

Table 1. Conversion of Product Quality Assessment (Azwar, 2015)

Guidance	Criteria
$X \geq (\mu + 1,5\sigma)$	Very Good
$\mu \leq X < (\mu + 1,5\sigma)$	Good
$(\mu - 1\sigma) \leq X < \mu$	Poor
$X < (\mu - 1,5\sigma)$	Very Poor

Table is used to convert the overall quality of the product and the quality of each aspect.

C. Research Finding

Characteristic of The Virtual Laboratory Media

The development of a virtual chemistry laboratory produced a web-based media. This medium can be used via smartphones or computers. The virtual laboratory consisted of purpose of the practicum, theory, MSDS (Materials Safety Data Sheet), tool introduction, practicum



interactive and tasks. The diagram of virtual chemistry lab can be seen in Figure 1.

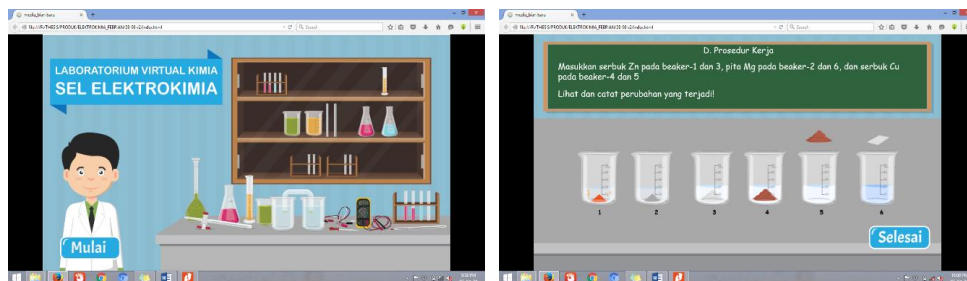


Figure 1. Views of Virtual Chemistry Laboratory
Implementation of The Virtual Laboratory Media

The average of students' achievement scores were shown in Figure 2.

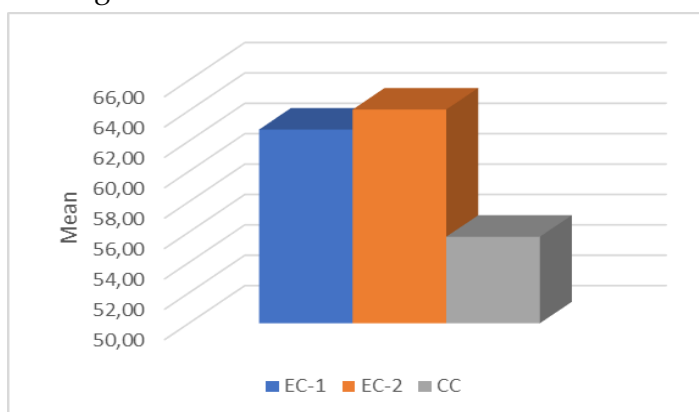


Figure 2. Graph of average student learning scores

Figure 2 shows that the average score in EC-2 is higher than that in EC-1 and in CC. Each score of students were then tested using Anova. The test was conducted to determine whether or not there were significant differences from the three classes. The results are listed in Table 2.

Table 2. Test of Homogeneity of Variances

Levene Statistic	df1	df2	Sig.
0.331	2	87	0.719



The homogeneity test of variance was found to be significantly greater than the alpha (0.05). This indicates that the variance of the three classes is homogeneous. Large F table with alpha 5% and degree of freedom 2 and 87 is 3.10. F table (3.10) was smaller than F count (3.929), this means the three classes had an average difference in scores. This average difference was indicated by the post hoc test results, the 2 classes that have the average difference were the CC class with the EC-2 class with a significance 0.032.

Evaluation of The Virtual Laboratory Media

The product assessment was conducted by 8 chemistry teachers spread in several districts. This assessment aims to get the quality of products that was developed. The instrument used was a 20 items questionnaire with a modified likert scale. The average conversion of this assessment results into product quality criteria uses a benchmark such as Table 3.

Table 3. Assessment Criteria

Score Range	Criteria
$X \geq 3,75$	Very Good
$2,5 \leq X < 3,75$	Good
$1,75 \leq X < 2,5$	Poor
$X < 1,75$	Very Poor

The conversion table is used to see the results of the assessment of this virtual laboratory product, either per item, per aspect or overall average value. For the results of this product assessment per item is set forth in Table 4.

Table 4. Product Assessment Score per Item

Criteria	Skor Mean	Item
Very Good	3.88	7,16
	3.75	1, 2, 4,5
Good	3.63	10, 13, 15, 17, 19
	3.50	3, 9, 12, 18, 20
	3.38	6, 8, 11, 14



The average score of the grain rating had a good quality. No items had below good quality. For the average score per aspect set forth in table 5.

Table 5. Average scores per aspect

Aspect	Mean	Criteria
Material	3,65	Good
Learning	3,54	Good
Technic	3,63	Good

All three aspects were in the good quality. This indicates that the quality of media in terms of material, learning and techniques. Overall, the average virtual laboratory product had a score of 3.59. This large average is on a good scale.

D. Discussion

Characteristic of The Virtual Laboratory Media

This virtual chemistry laboratory contained 4 practicum. There were spontaneous redox reactions, potential difference measurements, corrosion, and gilding. The laboratory view became the initial product of development and is ready to enter the validation stage. The virtual chemistry laboratory developed has been validated by chemists (two persons), media experts (one person), chemistry teachers (one person) and high school students (three students). The result indicated that the integrated virtual chemistry laboratory of hybrid learning was feasible for use with some revisions.

In previous research had resulted that virtual laboratory media can open via Android smartphone (Arista & Kuswanto, 2018). It was not opening via computers. In this research was web-based to be used on any smartphone (android or iOS), tablets and computer devices. Student devices are not only Android Smartphones, but also iOS, tablets and laptops. Students must have an internet connection to operate it. In doing the practicum, the user must complete first though it can be repeated from the beginning. Users should be careful in observing the results of lab work, especially if it opened by using a small sailing smartphone. This study was similar with previous research in components present in the virtual laboratory. Both of media consisted the



materials, virtual practicum, tasks and interactive media. It can facilitate students to practicum easier.

Implementation of The Virtual Laboratory Media

After revision from validators, the virtual chemistry laboratory was then used in the learning process. A total of 12 hours of lessons divided into 6 meetings were used for the process of practicum and learning as usual. At school meetings, CC and EC-2 got wet laboratory work by using real tools and chemicals. While EC-1 conducted activity using virtual laboratory in place of traditional laboratory work. The principle of activity of the two types of laboratory was the same, but there were differences in the materials used. There were 4 practicum in the virtual laboratory, but for CC and EC-2 only applied to 3 actual practice, spontaneous redox, corrosion, and gilding. The practicum of potential electrode measurement was replaced by video observation. It was because of the involvement of chemicals, the hydrogen gas that the school did not have. At an online meeting, EC-2 conducted practicum virtually using a virtual lab. While CC and EC-1 were only doing question-related to subject matter. The online meeting went well and was attended by all the students in the class. At the last meeting, students conducted a post test to measure the students' achievement on this electrochemical material.

The average difference was due to difference in the number of practicum performed. EC-2 obtained practicum in traditional laboratory and virtual laboratory. This class gained more experience in electrochemical material practice. The amount of experience gained by students makes the students understand the principles of the practice. In addition, EC-2 students also gain experience for practicum directly using a traditional laboratory. Compared with EC-2, CC and EC-1 get the practice with the same principle, but one time practicum. CC students get a real practical experience, but the practicum does not appropriate according to the theory. Real practice can only be done once due to time constraints. Students EC-2 and CC can develop their skills in the actual chemistry laboratory. EC-1 students only get virtual



laboratory only. Students in this class are not skilled in using chemical tools. They just get a virtual practicum visualization. The advantage of this group is that practicum can be done repeatedly and the results are definitely in accordance with existing theories.

Previous research, the use of virtual laboratory or the use of technology in learning can improve students' conceptual understanding (Arista & Kuswanto, 2018). In that study, there was 1 class with pretest-posttest design. The result could improve student learning outcomes. The study did not compare with a class using a traditional laboratory. Another study revealed that the use of a virtual laboratory or a traditional laboratory was nothing more effective (Hawkins & Phelps, 2013). In the study, the use of virtual laboratory as a substitute for traditional laboratory compared to traditional laboratory use as usual. The use of virtual laboratory as supplement is still rare in studies. This makes the study use these treatments. The use of virtual laboratory as supplements can make students more familiar with the principles of practicum performed.

Evaluation of The Virtual Laboratory Media

In average score per item, there were 6 items that had a very good quality. The items were the accuracy of the materials, the value of education in the product, the test in the product, the preparation of the report, the suitability of the need of students, and the relevance to the current technology. The virtual laboratory media has accurate material and has educational value to be applied in the learning process. Exercises in this media were developed through core competencies and basic competencies of electrochemical materials of the 2013 curriculum (national curriculum in Indonesia). This media can also assist students in preparing and producing practical reports. There is a composition of student worksheets that can be used as a reference to conclude the results of the practice. In addition, this technology-based media suits the needs of students today. Students have gadgets connected to the internet connection. This should be utilized in the learning process. By involving technology in learning, students are increasingly motivated in following the lesson.



On the aspect-based results, all three aspects are of good quality. These three aspects are the main aspects of the assessment. Materials in virtual labs are well presented and coherent, ranging from core competencies, basic competencies, the introduction of tools and materials, virtual lab work and tasks. This makes it easier for students to understand the material. In terms of learning, this medium can facilitate students in schools with limited tools, and materials. From a technical point of view, practicums with virtual labs are easily accessible anywhere, anytime, and by anyone.

This results mean that the virtual chemistry laboratory of electrochemistry material had a good quality and it is worthy to be used in the learning process as a supplement. In previous study, virtual laboratory that developed had a very good quality (Arista & Kuswanto, 2018). Assessments in the study were similarly using three main aspects, but one aspect was different from this research. These three aspects have very good qualities assessed by the teacher.

E. Conclusion

The conclusion of this research, characteristic of virtual chemistry laboratory that was developed can be opened through smartphone android or ios and also through computer device. This laboratory has good quality in terms of 3 main aspects, namely the aspects of materials, learning and technique. The use of a virtual laboratory as a supplement has a larger average than as a substitute and traditional laboratory. Class that use traditional laboratory with class using two different laboratory have a significant differences.

Suggestions for future research in order to do the development of virtual laboratory on other chemical materials. It can be used as an additional knowledge of high school students in understanding the chemistry.

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