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***Journal of Physics: Conference Series*:**

Effect of virtual chemistry laboratory toward cognitive learning achievement

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Abstract. The aim of the study was to determine the effect of using a virtual chemistry laboratory on students' cognitive learning achievement. The study sample was 163 eleventh grade students from two high school in Cilacap regency, Central Java, Indonesia and selected randomly. The research sample was divided into three groups, where each group had different learning activities. Learning activities in the CG were chemistry learning with the practicum in the traditional laboratory, EG-1 were chemistry learning with the practicum in the virtual chemistry laboratory, and EG-2 were chemistry learning with the practicum in traditional laboratory and virtual chemistry laboratory. The data were collected by multiple-choice test questions with 30 items and analyzed using ANOVA (Analysis of Variance). The result showed that the cognitive learning achievement of students in the EG was higher than the CG. This result indicates that there is an effect of using virtual chemistry laboratory on student's cognitive learning achievement. This result of the study can be used as a reference for chemical educators to be more creative and innovative in providing facilities to support the achievement of cognitive learning achievement.

1. Introduction

Virtual Chemistry Laboratory (VCL) is defined as a virtual learning environment that contains a simulation of chemical practicum activities. Virtual laboratories are also interpreted as a form of interaction between students and practical tools through a computer or smartphone [1]. The advantage of virtual laboratories is that it is safe, practicum time is more efficient, laboratory staff is not too necessary, laboratory tools do not have any risk to break down or to lose, and practicum cost is more saving. It is because all tools and substance of this practicum tend illusion [2]. The virtual laboratory acts as a supporter of conventional practicum and forms of e-learning promotion [3]. Laboratory experience is important and challenging. So, the virtual laboratory needed as a potential facility to mold interactive learning [4].

One characteristic of interactive learning is that students are involved more actively in the learning process than teachers. The role of the teacher is only as a facilitator and students as the main actors. Potential tools for achieving interactive learning through virtual laboratories are multimedia. Multimedia elements include text (print or e-book), sound, images, animation, videos, tables and graphs [5]. Various studies have reported the impact of adding multimedia to VCL. The results of the first study showed that the use of images, sound, and animation proved to have an effect on increasing knowledge retention tests [6]. The results of the second study indicate that simultaneous video and image presentation can strengthen memory in long-term memory [7]. The results of subsequent

studies state that the use of multimedia in learning can reduce the cognitive burden of students [8]. Finally, the overall effect on improving cognitive learning achievement [9].

The addition of multimedia in VCL needs to be adjusted to the characteristics of students so that cognitive learning achievement can be improved [5]. A study shows that students are more interested in using multimedia-based technology [10]. However, another fact is found that most educators have difficulty developing technology-based multimedia because of limited facilities and capabilities. This is predicted to inhibit the construction of students' knowledge and have an impact on cognitive learning achievement. Therefore, it is necessary to examine the effect of VCL which is equipped with multimedia on the cognitive learning achievement of students. Based on the results of the study it can also be known that multimedia standards are good and in accordance with the learning characteristics of students.

2. Material and methods

VCL influence testing toward cognitive learning achievement was done through quasi-experiment with post-test only design. The study began with the development of questions on cognitive learning achievement tests specifically for petroleum materials. Test questions that have been developed are then theoretically validated by instrument experts and organic chemists. The results of theoretical validation from experts in the form of judgment are complemented by criticism and suggestions as a reference for revisions (summarized in table 1).

Table 1. Details of development and results of the validation of test questions

Indicators of Competence Achievement	Problem form	Number of questions	Validation result instrument expert	Validation result organic chemist
Explain the process of oil and natural gas formation.	Multiple choices (5 choices)	10	• Written word error. • The answer choices are not equivalent. • Answer choices are directed at the cognitive level of analysis.	• Writing numbers that indicate the number of atoms C is not right.
Explain the separation technique using multilevel distillation.		9		
Analyze the impact of burning fuel on the environment and health.		11		

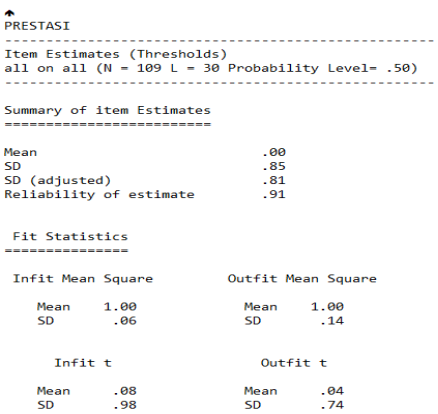
After theoretical validation by instrument experts and organic chemistry, test questions also need to be empirically validated by 109 students outside the research subject. Empirical validation is used to investigate the accuracy of each question in the test question. Each question is stated to be accurate if the students' understanding of consistency is obtained [11]. Empirical validation was analysis through Quest application until it was obtained reliability score of estimate and item fit (summarized in table 2).

Table 2. Reliability of estimate and item from Quest application

Instrument	Coefficient reliability of the estimate	Item amount (initial)	Item fit (end)
cognitive achievement tests	0.91	30	30

Reliability is measurement consistency; it means that measure was declared reliable if consistency score in a situation was the same. Inconsistency Measurement result was represented with reliability coefficient 0.00 [12]. while, consistency of measurement result is shown by the reliability coefficient approaching 1.00 [13]. Consistency item of cognitive tasks on table 3 was declared good because it is obtained reliability result of estimate approaching 1.0. Then, the amount of cognitive tasks of item fit

for post-test is 30, it means that all item is valid (there is no failed item) and it can be declared appropriated with the model. Item compatibility with the model can also be seen through INFT MNSQ value and OUTFIT MNSQ value about one, as well as INFT t value and OUTFIT t value about zero [14]. In this context, it is proven that it is obtained INFT MNSQ value and OUTFIT MNSQ value about one as well as INFT t value and OUTFIT t value about zero (See Figure. 1). it is clear on item fit map, where star sign is on two vertical lines dotted with the mean square scale 0.56-1.80 (See figure. 2).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Item Estimates (Thresholds)
all on all (N = 109 L = 30 Probability Level= .50)

Summary of item Estimates

Mean	.00
SD	.85
SD (adjusted)	.81
Reliability of estimate	.91

Fit Statistics

Infit Mean Square		Outfit Mean Square	
Mean	1.00	Mean	1.00
SD	.06	SD	.14

Infit t		Outfit t	
Mean	.08	Mean	.04
SD	.98	SD	.74

Figure 1. INFIT and OUTFIT value mean square

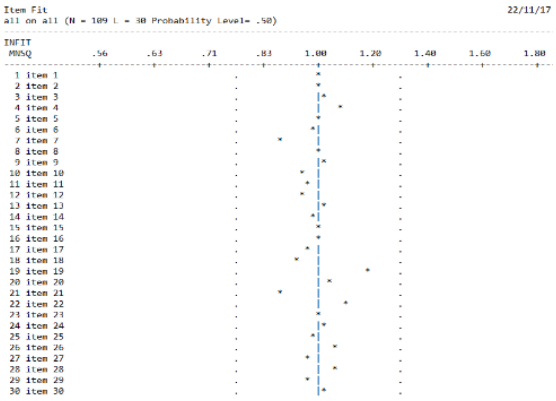

Figure 2. INFIT Value and OUTFIT t

Research subject involved is 163 eleventh learners from two senior high schools. Research subject was divided into three independent group, where every sample consisted of two classes. Every sample was treated randomly by different practicum model. It is based on normality test result where all classes are distributed normally with significances value bigger than 0.05 (summarized in table 3).

Table 3. Normality test for each class

Senior high school	Class	Kolmogorov-Smirnov Significance	Shapiro-Wilk Significance
A	1-XI (Natural science 1)	0.200	0.399
	1-XI (Natural science – 2)	0.190	0.098
	1-XI (Natural science – 3)	0.122	0.055
B	2-XI (Natural science – 1)	0.200	0.726
	2-XI (Natural science – 4)	0.200	0.876
	2-XI (Natural science – 5)	0.200	0.193

Next, six classes are grouped randomly into three independent group (summarized in table 4).

Table 4. Independent group are grouped

Independent group	Class	Amount (N)
CG	1-XI (Natural science – 3) 2-XI (Natural science – 5)	59
EG-1	1-XI (Natural science – 2) 2-XI (Natural science – 4)	51
EG-2	1-XI (Natural science – 1) 2-XI (Natural science – 1)	53

Each independent group has a different form of practicum (summarized in table 5).

Table 5. The form of practicum activities in each independent group

Group	Activity
CG	Practicum activities in conventional laboratories
EG-1	Practicum activities at VCL
EG-2	Practicum activities in conventional laboratories and VCL

Influence of VCL implementation toward cognitive learning achievement was analyzed through one way ANOVA helped by SPSS (*Statistical Product and Service Solutions*) *version* 21. However, before one way ANOVA analysis was done, two assumptions must be fulfilled as well as dependent variable every group distributed normal and homogeneity population variances [15]. In this research, first one way ANOVA assumption had been fulfilled because of significances value obtained bigger than 0.05 (summarized in table 6).

Table 6. Normality test result for each independent group

Group	Amount (N)	Shapiro-Wilk Significance	Lillifors significance
CG	59	0.109	0.100
EG-1	51	0.095	0.174
EG-2	53	0.091	0.072

While the third assumption related to Homogeneity population variances had also been fulfilled, where it is shown by significance value 0.753 or bigger than 0.05 (summarized in table 7).

Table 7. Homogeneity test result of population variances

Levene statistic	df1	df2	Significance
0.285	2	160	0.753

Overall, it can be concluded that the three assumptions above had been fulfilled, so analysis through ANOVA can be done.

3. Result and discussion

The results of the one-way ANOVA test were shown through the existence of statistically significant differences in cognitive learning achievement between students in the three independent groups (p-vale < 0.05) (summarized in table 8). This was proven through the acquisition of significantly smaller than 0.05, which is 0.00.

Table 8. The significant difference of every independent sample

	Sum of squares	Df	Mean square	F	Significance
Between groups	1308.408	2	654.204	8.301	0.000
Within groups	12609.901	160	78.812		
Total	13918.309	162			

Other findings indicate differences in the average cognitive learning achievement among students in three independent groups (see figure 3).

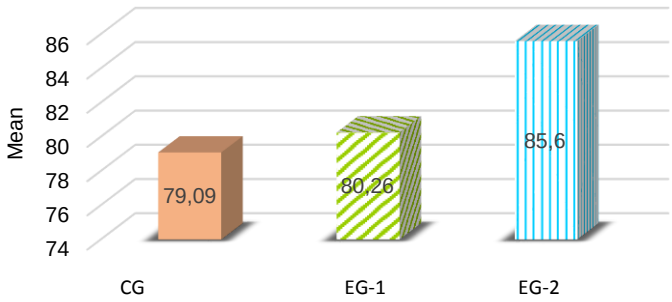

Figure 3. Differences in the average cognitive learning achievement in each independent group

Based on figure 3, it can be seen that students and the experimental group 2 had an average cognitive learning achievement higher than others. Some speculation arises relating to the reason of acquisition the highest average value on experimental group two. The first speculation relates to chemistry learning supported by practicum activity on conventional laboratory and VCL. A combination between virtual laboratory and remote laboratory had been done and impacted on understanding enhancement [16]. Virtual RTD laboratory application as support of conventional laboratory was also proven effective because it is produced the better concept of understanding [3]. The higher cognitive level was declared to be reached when laboratory technique and kinesthetic details were applied simultaneously [17]. Enhancement of understanding concept and skills also happen when the virtual instrument was combined with real practicum [18]. Practicum combination becomes tools to achieve high understanding and cognitive value because it is fulfilled representational competence [19].

Second speculation related to multimedia from practicum activity on conventional laboratory and VCL. In this context, the conventional laboratory has a role in giving media in the form of direct experience such as substance introduction and tools utilization, real practicum activity. While VCL contributed in giving media in the form of animation video, sound, virtual practicum simulation, learners' worksheet (PDF), and an introduction of 2D/3D practicum tools. Multimodal utilization was proven effective as detail information giver about physic/chemistry characteristic of substance as well as becoming chemistry theory ability enhancer [20]. Multimedia in the virtual laboratory was also reported impact on achievement enhancement [2]. Multimedia can also act as abstract chemistry material explainer, so it is obtained concept understanding as well as final value enhancement [21]. Another reason was conveyed through the results of research, where multimedia can play a role as a provider of detailed information about the physical or chemical nature of the material. Multimedia is also stated to be useful as an explanatory abstract chemical material, so as to gain an understanding of concepts and increase in the final value. Based on various research results above, so it can be concluded that better understanding can be reached through multimedia such as simulation; interactive animation; video lectures; and lab view video [22]. In this context, multimedia must interact and be interrelated with each other in order that experiment activity run more effective.

4. Conclusion

Statistically, it can be concluded that there are significant differences in cognitive learning achievement between students who conduct practicum activities in conventional laboratories, VCL and practicum activities in conventional laboratories and VCL has higher cognitive learning achievement than others. This finding can be the basis of subsequent research, especially related to the combination of practicum activities and a more varied presentation of multimedia so that higher cognitive learning achievement is achieved. In the next study also needs to examine the effect of a combination of practicum activities on other academic performances such as learning motivation, creativity or scientific attitude.

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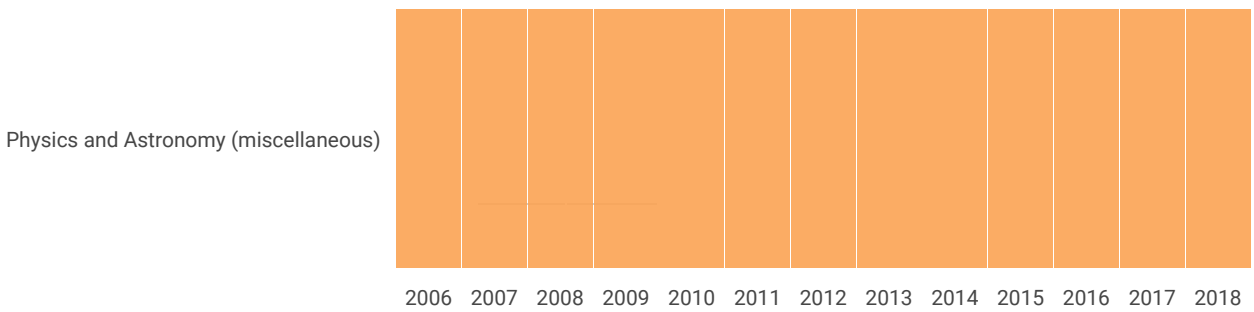

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