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## Improving Higher Order Thinking Skills via Semi Second Life

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**Abstract:** This study was conducted to determine the effectiveness of virtual laboratory based on semi second life (s-SL) on higher order thinking skills of general senior secondary school in chemistry learning process. The research design was adopted posttest-only design approach to a quasi-experimental. This study was conducted in the one of public general senior secondary school in 3T regions – Bangkalan City – one of the cities in East Java Province, Indonesia. There were 81 students in the grade 11 of natural science who involved in this study. The participants were divided into three groups, namely the students who did practical work by demonstration methods in chemistry real laboratory, the students who did practical work by experiment methods in virtual laboratory based on s-SL, and the students who did practical work by combination both of them (demonstration methods in chemistry real laboratory and experiment methods in virtual laboratory based on s-SL). The students in each group was tested by posttest of higher order thinking skills. The data was analysed with one-way ANOVA. The results of data analysis shows that there is a significance difference of each groups. Virtual laboratory based on s-SL has enough effect on the students' higher order thinking skills.

**Keywords:** *Chemical Equilibrium, higher order thinking skills, virtual laboratory, semi second life.*

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### Introduction

Optimizing the use of information, communication, and technology (ICT) in education is one of the government of Indonesia efforts to produce high-achieving generations. Teachers as professional educators also need to apply ICT in their lesson plan. Using of ICT in learning process can make it more interesting and improve student learning achievement (Jagodzinski & Wolski, 2015), effective (Hussain et al., 2017), and time efficient (American Chemistry Society, 2012). The government of Indonesia has shifted paper and pencil-based national test to computer-based national test in order to help teachers be adaptive to the development of science and technology. This should encourage teachers to get students involved in the ICT-based learning process. Based on the Center for Educational and Cultural Data and Statistics (2018), the quantity of public and private general senior secondary school in Indonesia that have computer laboratory is 10,605 out of 13,692. This quantity is more than the quantity of chemistry laboratory that is only 5,265. The quantity of public and private general senior secondary school that have computer laboratory can be an opportunity for teachers to use them as a learning media, especially in 3T regions in Indonesia.

3T is an abbreviation for the regions in Indonesia that are frontier, outermost, and underdeveloped. There are many regions in Indonesia that was categorized as 3T. One of them is Bangkalan Regency, East Java Province, Indonesia. Based on the preliminary research, power point is the most favourite of chemistry teachers as media learning (Amin & Ikhsan, 2020). Power point is used for presentation media to transfer knowledge by teacher to students or by students to the students. The chemistry teachers have not optimized the using computer laboratory in chemistry learning process. The chemistry learning process always involve practical work because almost all of the content of chemistry is obtained based on facts. The students can confirm information that learned from the teacher and/or textbooks by practical work. The results study of Ghani et al. (2016) shows that practicum provide real experiences and try the students to develop skills of analysis, evaluate, and design experiments. Unfortunately, the results of this study have not been fully utilized in the chemistry learning process, especially in Bangkalan Regency. The absence of chemical laboratory and/or instruments, no laboratory assistant, and the limited of time allocation in the one of topic are the

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main reasons to reduce the implementation of chemistry practical in the schools (Solikhin et al., 2019a). This condition will impact to the achievement level of the students' basic competencies in the educational curriculum.

The education curriculum in Indonesia is curriculum 2013 revised 2018 (Ministry of Education and Culture, 2018). It is abbreviated as K-13. The learning process in K-13 requires students to attain basic competency which train higher order thinking skills (HOTS). It's seemed formulation of basic competency for cognitive aspects that uses operational verbs from HOTS indicators, like as explaining, analysing, and evaluating. The government of Indonesia synchronize them to the national test that contains HOTS questions (Ministry of Education and Culture, 2019). The students faced various difficulty to solve the items of national test, like as applying a concept to an unfamiliar context, predicting based on data from several variables, and interpreting experimental/practicum data in pictures/graphs, and tables (Center for Educational Assessment, 2018).

The difficulties experienced by students to solve the items of chemistry national test based on HOTS has impact to the lack of achievement of a subject indicator. One of them is a chemical equilibrium. Based on the results of the 2018/2019 national test of chemistry, the quantity of students who achieved this indicator was below 44%. This indicates that the HOTS of students can be said to be low categorized. Based on the preliminary research to the teachers' chemistry and students of natural science in Bangkalan City, the minimum achievement of students' HOTS is also caused by time allocation in the K-13. In the K-13, the schedule of chemical equilibrium is learned at the end of the semester in the grade 11 of natural science. This schedule is very close to the end of the semester assessment schedule, so that why the chemistry teachers did not give practical work on chemical equilibrium. This fact was also proved by Rahayu and Sutrisno (2019) that students in the control group only had a mean score of HOTS is 50.72. The results study of Ichsan et al. (2019) about elementary to master students' HOTS in Indonesia was also low category.

### *Literature Review*

#### *Chemical Equilibrium*

Chemical equilibrium is chemical reaction that can occur in either direction (Whitten et al.). This reversible reaction will be exists in chemical equilibrium when the concentration of all reactants and products remain constants with time (Zumdahl & Zumdahl., 2010). This reaction has appear stopped because there are no changes in macroscopic. In fact, there is a reaction in sub microscopic so it called dynamic equilibrium. Because of this characteristic, chemical equilibrium considered one of the most difficult in the general senior secondary school chemistry (Karpudewan et al., 2015) and experienced misconception (Jusniar et al., 2020). Various studies have been carried out to visualize the process of chemical equilibrium. One of them is developing a discovery learning module on chemical equilibrium (Ellizar et al., 2018) and develop virtual laboratory (Ollino et al., 2017).

#### *Higher Order Thinking Skills (HOTS)*

Dimension of cognitive process is differed 6 levels based on Taxonomy Bloom Revision. They are remembering, understanding, applying, analyzing, evaluating, and creating (Anderson et al., 2001). Brookhart (2010) categorize the three last of them as HOTS. Analyzing involve breaking down information or object into its part and make a certain about the relation of each parts to an overall structure. Evaluating is defined as making a judgment based on criteria and standard. The criteria is about quality, effectiveness, efficiency, and consistency. Creating is the last levels of cognitive process dimension. Creating involve putting elements together to form a coherent or functional whole. One of the efforts to train students' HOTS in chemistry learning process is to involve students in practical work (Malik & Setiawan, 2015). Practical work can be carried out in the virtual laboratory (Winkelmann et al., 2017; Hawkins & Phelps, 2013; Herga & Dinevski, 2012). One of them is second life (SL).

#### *Semi Second Life (s-SL)*

Second Life (SL) is multi-user virtual environments (MUVES) which is represented by avatar as user in online virtual environments (Winkelmann, 2013). SL uses a programming language which is said to be Linden Scripting Language (LSL) to design all of virtual 3D objects and its action. Avatar in SL can interact with another avatar by communication like as message via chat or sound via headset and microphone (Luo, 2008). The users can control avatar's action by keyboard and mouse. SL provides some features that interest designer and user. Some of the advantages and disadvantages of SL that can be used as a laboratory design platform are presented in Table 1 (Winkelmann, 2013; Wang & Burton, 2012; Inman et al., 2010; Brown & Sugar, 2009; Salt et al., 2008).

Table 1. The Advantages and Disadvantages of SL

No	Advantages	Disadvantages
1.	Virtual objects are 3D so they are more like the real conditions than 2D.	Requires high bandwidth and speed of internet access.
2.	Free for account creation.	Not recommended for children under 18 years of age.
3.	There is an avatar that represents the user engaging in virtual activities.	The user cannot log in via the internet at the school.
4.	Provides interactive features (between avatars as users can communicate in the form of text, gestures, or internet connected languages).	The user will be charge to build and to keep the room in SL.
5.	Creating distance learning.	Requires a computer that has high specifications.

Based on the consideration of the weaknesses of SL which are listed in Table 1, a semi SL (s-SL) as virtual laboratory was designed. Semi Second Life (s-SL) is a modification form to second life feature. This modification is appropriated with strengthens and opportunity which are had general senior secondary school in Bangkalan Regency. Semi is defined as partially. It means that having some characteristics of something. Based on definition of semi, the s-SL as virtual chemistry laboratory is computer software that simulates practical work with some of its features resembling an SL as virtual laboratory. These features include an avatar that represents students, a zoom feature that can help students mark measurement limits on glassware, data recording results depend on student actions, tools and chemicals are controlled by student actions, interactivity forms are navigated by a keyboard and mouse and some sub microscopic level visualizations in the form of animation.

Semi second life (s-SL) was designed to comply with request of teachers' chemistry in Bangkalan City, East Java Province, Indonesia. The display of its is relevant to students' learning style and facilities in general senior secondary school in Bangkalan City. To use the s-SL application, students follow the teacher's instruction and solve the proposed activities in computer laboratory in the school. They can do it by themselves as homework if they have a computer that support to install it. In this case, they can observe, analysis, evaluate, and make conclusions based on chemical equilibrium concept. The s-SL activities are carried out by an individual or group student on a personal computer (PC) that supports 3DUnity. PC with a mouse was chosen to view and operate it easily.

## Methodology

### Research Goal

This study aimed to know the significant difference of students' HOTS in the control groups (CG) that the students did practical work by demonstration methods in chemistry real laboratory, first experimental groups (EG-1) that the students did practical work by experiment methods in virtual laboratory based on s-SL, and second experimental groups (EG-2) that the students practical work by practical work by combination both of them (demonstration methods in chemistry real laboratory and experiment methods in virtual laboratory based on s-SL). This study was also aimed to know the effectiveness magnitude of virtual laboratory based on s-SL on general senior secondary school students' HOTS in chemistry learning process on chemical equilibrium topic. The research hypothesis of this study is

$H_0$  : The population means of students' HOTS in the CG, EG-1, and EG-2 are not statistically significant difference.

$H_1$  : The population means of students' HOTS in the CG, EG-1, and EG-2 are statistically significant difference.

### Research Design

Posttest-only design approach to a quasi-experimental design was adopted in this study (Creswell, 2012). Table 2 shows the research design by detail.

Table 2. Posttest-only Design

No	Aspect	Treatments	Experimental Groups	
		Control Groups	1	2
1.	Learning Process	Discovery learning Worksheet	Discovery learning Worksheet	Discovery learning Worksheet
		Practical work by demonstration methods in chemistry real laboratory	Practical work by experiment methods in virtual laboratory based on s-SL	Practical work by combination both of them (demonstration methods in chemistry real laboratory and experiment methods in virtual laboratory based on s-SL)
2.	Objective Learning	Diagnostic two tier as posttest of higher order thinking skills		

There was an intervention of each group to demonstrate causality between independent and dependent variables. The independent variable of this study is the implementation model of practical work as a learning methods in chemistry learning process on chemical equilibrium. There were three level of this treatments, namely 1) control groups that used demonstration methods in chemistry real laboratory, 2) first experimental groups that used experiment methods in virtual laboratory based on semi second life (s-SL), and 3) second experimental groups that used combination both of them (demonstration methods in chemistry real laboratory and experiment methods in virtual laboratory based on s-SL). For the level of treatments in this study, the experimenter did not allow to artificially create groups. It means that there was no random assignment for participants to groups. The experimenter also did not control all of control variable like as participants' mood. So that why, posttest-only design approach to a quasi-experimental design was feasible adopted in this study (Krishnan, 2018). Whereas, the dependent variable in this study is higher order thinking skills.

#### *Participant of the Study*

Stratified sampling was chosen as sampling technique in this study. It was conducted in the public general senior secondary school in 3T regions – Bangkalan City – one of the cities in East Java Province, Indonesia. The determination of public general senior secondary is based on the following criteria, namely 1) implementation curriculum 2013 revision 2018, 2) has been accredited A, 3) has chemistry real laboratory and/or computer laboratory, and 4) the students familiar to operate the computer. Based on these steps, public general senior secondary school 4 Bangkalan was selected. There were 81 students in the grade 11 of natural science. The students was divided into three groups, namely control groups (CG), first experimental groups (EG-1), and second experimental groups (EG-2). There was 26 students in the CG, 28 students in the EG-1, and 27 students in the EG-2.

#### *Methods of Data Collection*

There were two types of data collection techniques in this study. They were questionnaire and test. The questionnaire was given to the three expert judgments of theory validity on test instrument of higher order thinking skills. Three expert judgments need to have similar qualification. First, lecture in chemistry education, chemistry, or evaluation which is accredited A from Yogyakarta State University or the others state university. Second, three expert judgment has done magister program as minimal in chemistry education, chemistry, or evaluation. The each of expert judgments used Guttman scale (yes or no) to judge the each indicator in the theory validity. The test technique was used to measure the students' higher order thinking skills when posttest was given.

#### *Data Collection Instruments*

Based on data collection techniques, there were also two types of data collection instruments, namely questionnaire and test instrument. There were 19 statements of questionnaire. They were about the substantial and constructional of the test instrument. The initial test instrument consist of 15 items. The blueprint of this test instrument is shown in Table 3.

*Table 3. Blueprint of Test Instrument*

No	Aspect of HOTS	Indicator	No items
1.	Analysis (C4)	Explaining the concept of chemical equilibrium in its application	1
		Differentiating homogeneous and heterogeneous equilibrium reactions	2
		Analysing equilibrium constant ( $K_c$ dan $K_p$ ) based on concentration or partial pressure of reactant or product	3,4
		Identifying variable that affect chemical equilibrium in daily life	8,9,10,11,12
2.	Evaluate (C5)	Determining the composition of substance in equilibrium	5,6
		Determining percent dissociation of chemical equilibrium	7
		Concluding the factors that affect chemical equilibrium	13,14
3.	Create (C6)	Formulating hypothesis about the factors that affect chemical equilibrium	15

The test instrument was formed in diagnostic two tier. The first tier was arranged in multiple choice with five alternative response options (A, B, C, D, and E). The second tier was proposed to give the reason of the first tier that has chosen. It was arranged in open-ended answers.

#### *Validity and Reliability of the Instrument*

The test instrument was tested to 170 students who has received contents of chemical equilibrium before being posttest instrument. This aimed to know the validity of empirical and reliability of the test instrument. The result of empirical validity was analysed based on Rasch Model with Winstep Program. This data was based on item fit in Rasch

Model (Boone et al., 2014). The item will be valid if fulfill two-three criteria of item fit in Rasch Model, namely 1)  $0.5 < \text{the value of outfit mean square (MNSQ)} < 1.5$ ; 2)  $-0.2 < \text{the value of outfit Z-Standard (ZSTD)} < +2.0$ ; and 3)  $0.4 < \text{the value of point measure correlation (Pt Mean Corr)} < 0.85$  (Sumintono & Widhiarso, 2015). The reliability of the test instrument was also analysed based on Rasch Model with Winstep program. The criteria reliability of the test instrument was based on Cronbach's alpha as shown in Table 4 (Sumintono & Widhiarso, 2015).

Table 4. Cronbach's Alpha

Reliability	Criteria
< 0.5	Low
0.5 – 0.6	Enough
0.6 – 0.7	Moderate
0.7 – 0.8	Good
> 0.8	Very good

#### Data Analysis

The answers of each student were corrected by allowing scoring rubrics. The scoring rubric was adopted from Ad'hiya and Laksono (2018). The each item is given 0, 1, 2, 3, 4, or 5 as a score. The each score has a description as shown in Table 5.

Table 5. Scoring Rubrics

Score	Description
0	There are no answer on multiple choice (tier one) and reason (tier two)
1	The answer on multiple choice as tier one is wrong
2	The answer on multiple choice as tier one is true but without reason on tier two
3	The answer on multiple choice as tier one is true but the reasons on tier two are wrong
4	The answer on multiple choice as tier one is true but the reasons on tier two are true for incomplete
5	The answer on multiple choice as tier one is true but the reasons on tier two are true for complete

A gain of score total for each student was converted to the value. The formula of converting is

$$\text{Value} = \frac{\text{Students score that obtained}}{\text{Maximal score that obtained for all items}} \times 100$$

Furthermore, the data was processed using IBM SPSS Statistics (Version 22). One-way analysis of variance (one-way ANOVA) was used for the statistically analysis to test the research hypothesis of this study. One-way ANOVA could apply after six assumptions ANOVA was filled (Kirk, 1995). The results of this test are:

1. Higher order thinking skills as dependent variable has interval or ratio data.
2. Independent variable for this study has nominal data. Number 1 is a sign for CG whose practical work are carried out by demonstration methods in chemistry real laboratory. Number 2 is a sign for EG-1 whose practical work are carried out by experiment methods in virtual laboratory based on s-SL. Number 3 is a sign for EG-2 whose practical work are carried out by combination both of them (demonstration methods in chemistry real laboratory and experiment methods in virtual laboratory based on s-SL).
3. The identity of each student in CG, EG-1, and EG-2 is different. It means that there is no relationship between subjects of this study.
4. There is no outliers sign (o) in the Box and Whisker Plots. It indicated dependent variable data does not contain outliers. This result is shown in Figure 1.

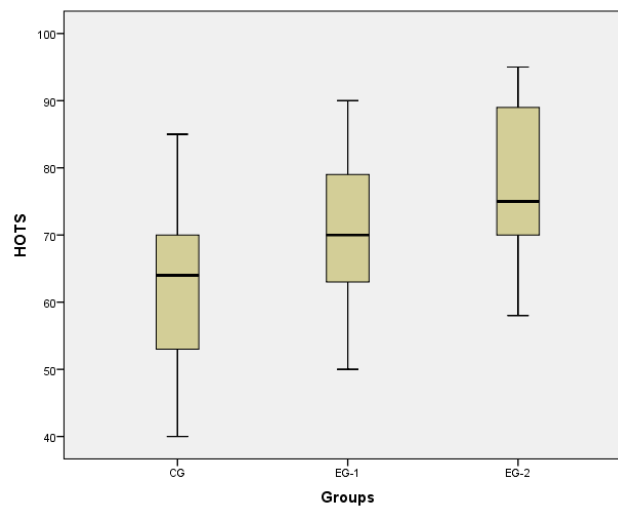


Figure 1. Box and Whisker Plots

5. Each independent groups has dependent variable data that is normally distributed, namely  $p$ -value  $> 0.05$ . The results of the normality test with Shapiro-Wilk test are listed in Table 6.

Table 6. Shapiro-Wilk Test

Independent Group	Sample	p-Value of HOTS
CG	26	0.901
EG-1	28	0.935
EG-2	27	0.162

The results show that the assumption of normality was distributed normally. It was shown by each independent groups has  $p$ -value  $> 0.05$ . The  $p$ -value of HOTS of CG, EG-1, and EG-2 is 0.901, 0.935, and 0.162, respectively.

6. Each independent group has homogeneous dependent variable data, namely  $p$ -value  $> 0.05$ . The results of the homogeneity test with Levene's test are displayed in Table 7. The results show that the assumption of homogeneity of variance was no violated because  $p$ -value of HOTS is 0.810  $> 0.05$ .

Table 7. Homogeneity Test

Independent Group	Sample	p-Value of HOTS
CG	26	0.810
EG-1	28	
EG-2	27	

The effectiveness magnitude of using virtual laboratory based on s-SL to the students' higher order thinking skills is based on the value of partial eta squared ( $\eta^2$ ) (Richardson, 2010). The value of  $\eta^2$  is interpreted as the effect size which is presented in Table 8 (Muijs, 2004).

Table 8. Interpretation of Partial Eta Squared as Effect Size

Effect Size	Category
$< 0.1$	Low
$< 0.3$	Enough
$< 0.5$	Moderate
$< 0.8$	Strong
$\geq 0.8$	Very strong

#### Intervention: Implementation of Study

This study was conducted on November 2019 in public general senior secondary school 4 Bangkalan, Indonesia. It was involved all of students in the grade 11 of natural science. There were 81 students that was divided into three groups, namely CG, EG-1, and EG-2. The difference of each group was the implementation model of practical work as a learning method in chemistry learning process on chemical equilibrium. It was done to know the effectiveness independent

variable to the higher order thinking skills as dependent variable in this research. This study was done within three weeks with 6 meetings and the last meeting was used to the test. There were five sub topics of chemical equilibrium that was given to the student in each group. They were dynamic equilibrium, type of chemical equilibrium, equilibrium constant, percent dissociation, and factors that affect chemical equilibrium. This part was the difference of each group that shown by Table 9.

*Table 9. Lesson Plan in Three Groups*

<b>Group</b>	<b>Activities in Learning Process</b>
CG	Students are given a stimulus about problems that are presented in the worksheet by discovery learning models Students are guided to identify the problems that are presented in worksheet and write the hypothesis Some of students did practical work by demonstration methods in chemistry real laboratory, representatively, to collecting and processing data The students discussed the results and presentation The students answer the question that are presented in worksheet
EG-1	Students are given a stimulus about problems that are presented in the worksheet by discovery learning models Students are guided to identify the problems that are presented in worksheet and write the hypothesis Each student did practical work in the virtual laboratory based on s-SL to collecting and processing data The students discussed the results and presentation The students answer the question that are presented in the virtual laboratory based on s-SL
EG-2	Students are given a stimulus about problems that are presented in the worksheet by discovery learning models Students are guided to identify the problems that are presented in worksheet and write the hypothesis Students combined chemistry real laboratory by demonstration methods and virtual laboratory based on s-SL to do practical work The students discussed the results and presentation The students answer the question that are presented in virtual laboratory based on s-SL

All of students in each group received a worksheet based on discovery learning. It contained some questions to guide the students to construct their own knowledge. In the first meeting, all of students in each group received dynamic equilibrium and type of chemical equilibrium. Equilibrium constant and percent dissociation were given on the second and third meeting. It was also consumed twice meeting on the factors that affect chemical equilibrium.

## **Results**

### *Validity and Reliability of the Instrument*

There were fifteen items as the initial test instrument of higher order thinking skills. It was tested to 170 students who have received contents of chemical equilibrium. The answers of each student were given a score by following scoring rubric in Table 5. The score total that each student obtained is converted to the value. The all of value of students are analysed with Winstep Program. The result is shown in Table 10.

Table 10. Item Fit of Test Instrument

Entry Number	Total Score	Infit		Outfit		Pt-Measure	
		MNSQ	ZSTD	MNSQ	ZSTD	CORR.	EXP.
5	193	1.64	5.0	1.96	5.4	A .49	.58
4	98	1.11	.9	1.67	2.9	B .38	.47
1	403	1.20	1.8	1.42	3.2	C .16	.62
10	266	1.34	3.1	1.12	1.0	D .66	.62
8	240	1.27	2.5	1.33	2.4	E .54	.61
13	90	1.29	2.0	1.11	.6	F .47	.45
3	591	1.16	1.2	1.01	.2	G .39	.56
15	110	1.09	.7	.72	-1.6	H .58	.49
14	107	1.07	.6	.70	-1.7	g .58	.48
12	198	1.05	.5	.84	-1.1	f .73	.59
9	183	.69	-3.2	.81	-1.4	e .64	.58
2	206	.78	-2.2	.76	-1.9	d .64	.59
7	229	.63	-4.0	.67	-2.8	c .67	.61
6	134	.62	-3.8	.59	-2.7	b .68	.52
11	234	.52	-5.6	.53	-4.5	a .71	.61
<b>Mean</b>	218.8	1.03	.0	1.02	-.1		
<b>S.D.</b>	126.7	.31	2.9	.40	2.6		

Based on Table 10, there were three items that no filled the item fit criteria. Items 5 only filled one of three criteria item fit, namely  $0.4 < \text{Pt Measure Corr} < 0.8$ . Item 1 and item 4 did not fill the criteria for item fit. Therefore, the three items were declared unfit, so they were not used in this study. This study used eight items to be posttest instrument of higher order thinking skills. The results of empirical validation also inform the reliability of items in Rasch Model. The result of reliability is shown by Table 11. Based on the Table 11, the value of Cronbach's alpha is 0.87. It means that the reliability of the test instrument is very good.

Table 11. Reliability of Test Instrument

	Total Score	Count	Measure	Model Error	Infit MNSQ	ZSTD	Outfit MNSQ	ZSTD
<b>Mean</b>	19.3	15.0	-1.77	.31				
<b>S.D.</b>	10.3	.0	.87	.14				
<b>Max.</b>	41.0	15.0	-.27	1.76				
<b>Min.</b>	.0	15.0	-6.04	.24	.25	-3.1	.14	-3.1
<b>Real RMSE</b>	.40	<b>True SD</b>	.77	<b>Separation</b>	1.92	<b>Person Reliability</b>		.79
<b>Model RMSE</b>	.34	<b>True SD</b>	.80	<b>Separation</b>	2.35	<b>Person Reliability</b>		.85
<b>S.E. of Person Mean = .07</b>								
<b>Person Raw Score-to-Measure Correlation = .94</b>								
<b>Cronbach Alpha (KR-20) Person Raw Score "Test" Reliability = .87</b>								

#### One-way ANOVA

The aims of one-way ANOVA is to test the means of  $p \geq 2$  populations (Kirk, 2008). The means of populations in this study consists of CG, EG-1, and EG-2. One-way ANOVA was used to test this research hypothesis. The results of one-way ANOVA will give information about rejection or acceptance to the null hypothesis ( $H_0$ ). The null hypothesis ( $H_0$ ) will be rejected if  $p\text{-value} < 0.05$  at  $\alpha = 5\%$ . Rejection of null hypothesis caused the alternative hypothesis ( $H_1$ ) is tenable. The result of one-way ANOVA test is shown in Table 12.

Table 12. The Result of Hypothesis Test with one-way ANOVA

	Sum of Squares	df	Mean Square	F	p-value
Between Groups	2759.868	2	1379.934	11.642	.000
Within Groups	9245.688	78	118.534		
Total	12005.556	80			

Based on Table 12, it showed that the null hypothesis is rejected because  $p\text{-value } 0.000 < 0.05$  at  $\alpha = 5\%$ . It means that the alternative hypothesis is tenable. The population means of students' HOTS in the CG, EG-1, and EG-2 are statistically significant difference. It indicates that virtual laboratory based on s-SL has an effect on students' HOTS. Unfortunately,



Kirk (2008) stated that rejection of  $H_0$  does not mean that all of the population means are different. PostHoc test is the best way to determine which groups differ (Homack, 2001). Because the sample size is not equal and homogeneity is equal, so LSD test is applied in this study. The result of LSD test is shown in Table 13.

Table 13. PostHoc with LSD Test

Independent Group		Mean Difference	p-Value
CG	EG-1	-7.157*	0.018
	EG-2	-14.433*	0.000
EG-1	CG	7.157*	0.018
	EG-2	-7.276*	0.015
EG-2	CG	14.433*	0.000
	EG-1	7.276*	0.015

Based on Table 13, it can be seen that all of the population means are not equal. All of the pairwise combinations of group means was significant difference at a specific level of significant ( $\alpha$ ) = 5%. Population means of CG is significant difference with EG-1 (p-value = 0.018 < 0.05). Besides that, population means of EG-1 is also significant difference with EG-2 that was proven by p-value = 0.015 < 0.05 at  $\alpha$  = 5%. Additionally, the population means of EG-2 is also significant difference with CG (p-value = 0.000 < 0.05). The significant difference for all of the pairwise combinations of group means can be seen by the results of its statistic descriptive in Table 14.

Table 14. Statistic Descriptive

Independent Group	Sample	Mean	Std. Deviation	Std. Error	Minimum	Maximum
CG	26	63.31	11.124	2.182	40	85
EG-1	28	70.46	10.261	1.939	50	90
EG-2	27	77.74	11.282	2.171	58	95

Based on data in Table 14, the mean scores related to the value of higher order thinking skill in each group. EG-2 is the highest mean score (77.74) with Std. Deviation 11.282. The mean difference of EG-2 with EG-1 and CG are 7.276 and 14.433, respectively. For all of the three groups, CG is the lowest mean score (63.31) with Std. Deviation 11.124. The mean score of EG-1 is 70.46 with the minimum score is 50 and maximum score is 90. The mean difference of EG-1 with CG is 7.157 like as displayed in Table 13.

#### *Effectiveness Virtual Laboratory based on Semi Second Life (s-SL)*

This study implemented the virtual laboratory based on s-SL in chemistry learning process on chemical equilibrium. This study involved the control and experimental groups. The virtual laboratory based on s-SL was applied in the experimental group. The experimental groups consist of first experimental group (EG-1) and second experimental group (EG-2). EG-2 had twice opportunity to do practical work, namely practical work by demonstration methods in chemistry real laboratory and by experiment methods in virtual laboratory based on s-SL. So, it is the different with EG-1. The students in EG-1 did practical work by experiment methods in virtual laboratory based on s-SL. Whereas, some students in CG did practical work by demonstration methods in chemistry real laboratory, representatively.

The implementation of virtual laboratory based on s-SL was conducted on factors that affect chemical equilibrium. It was taken twice of six times meeting for all of topic chemical equilibrium. In the last meeting, the effectiveness of virtual laboratory based on s-SL was measured to higher order thinking skills. The effectiveness results of virtual laboratory based on s-SL was obtained based on the univariate general linear model test (GLM). Table 15 shows the result of univariate GLM. The effectiveness of implementation virtual laboratory based on s-SL to the students' HOTS is based on the value of partial eta squared ( $\eta^2$ ) (Richardson, 2010). The  $\eta^2$  in Table 15 is 0.230. It means that the effect of implementation virtual laboratory based on s-SL on higher order thinking skills is categorized enough.

Table 15. The Result of Univariate GLM

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
<b>Corrected Model</b>	2759.868 <sup>a</sup>	2	1379.934	11.642	.000	.230
<b>Intercept</b>	402270.292	1	402270.292	3393.699	.000	.978
<b>Groups</b>	2759.868	2	1379.934	11.642	.000	.230
<b>Error</b>	9245.688	78	118.534			
<b>Total</b>	415654.000	81				
<b>Corrected Total</b>	120005.556	80				

### Discussion

The higher order thinking skills of students in the CG and EG showed a significant difference. The CG is a group of students who did practical work on the sub topic "factors that affect chemical equilibrium" by demonstration methods with discovery learning in chemistry real laboratory. The EG-1 is a group of students who did practical work on the same as sub topic in CG by experiment methods with discovery learning in the virtual laboratory based on s-SL. Whereas, the EG-2 is a group of students who did practical work on the same as sub topic in CG and EG-1 by demonstration methods in chemistry real laboratory and experiment methods with discovery learning in the virtual laboratory based on s-SL. Therefore, the main factor that caused population means of CG is significant difference with EG-1 or EG-2 and population means of EG-1 is also significant difference with EG-2.

The higher order thinking skills of students in EG-1 and EG-2 were trained by practical work in virtual laboratory based on s-SL. The students are given a stimulus about problems that are presented in the worksheet by discovery learning models. The students are guided to identify the problems that are presented in worksheet and write the hypothesis. Furthermore, the students did practical work in the virtual laboratory based on s-SL to collecting and processing data. At this stage, the students are given the opportunity to make mistakes three times during practical work. This feature is made to resemble the conditions in chemistry real laboratory which allows every student to make mistakes. This feature proposed to the students for analysis and evaluate where the mistakes were made. The mistakes caused the students unable to proceed the next steps. So, it could be concluded that students had not been able to design an experiment. Therefore, Kirschner and Huisman (1998) states that virtual laboratories are the best multimedia that can be used to help students to achieve higher cognitive levels, such as analysis, synthesis, and evaluation.

Students who successfully design experiments in virtual laboratory based on s-SL get an explanation of the concept at three levels of chemical representation, namely macroscopic, symbolic, and sub microscopic (Herga et al., 2016). The sub microscopic level is represented by 3D dynamic visualization found in the virtual laboratory based on s-SL. In the virtual laboratory, the students can simultaneously carry out practical work such as in chemistry real laboratory and monitor changes that occur at the macroscopic and sub microscopic levels (Tatli & Ayas, 2013). The existence of an explanation of the concept at the sub microscopic level that is visualized in 3D dynamically can help the imagination of students to the process of chemical equilibrium so that it can improve their understanding. The result study of Rizki et al. (2018) also showed that virtual chemistry laboratory can provide the depth understanding of sub microscopic to the students. Practical work in chemistry learning can provide opportunities for students to demonstrate various skills (Demircioglu & Yadigaroglu, 2011). Skills related to chemical laboratory activities are higher order thinking skills (Ramadhan & Irwanto, 2017).

Another reason behind the differences in the achievement of higher order thinking skills of students in the CG and EG-1 is the number of opportunities to do practical work. Students in the CG only got one chance to practice through the demonstration method. This is done because the number of instruments that can function properly is only one set and the chemicals used are very limited and sourced from researchers. Therefore, each student in the control class does not get direct experience because they are represented by their friends doing practical work through demonstrations so that the knowledge gained is not complete. Students also can not repeat the practicum when they make mistakes during practical work. The results study of Solikhin et al. (2019b) also revealed that the students in the control class only got once to do practical work because time constraints. It caused the students in the control class had the lowest mean score of students' achievement.

Every student in the EG-1 got the same opportunity to do practical work in the virtual laboratory based on s-SL. Every student is free to carry out practical work repeatedly anywhere and anytime without being tied to the number of instruments and chemicals in the school. Each student becomes more active due to repeated opportunities given to carry out the practical work in the virtual laboratory based on s-SL. Therefore, they can familiarize students with the discovery learning models (Yulianti et al., 2012). This finding was also supported by the results study of Herga and Dinevski (2012). Students in the experimental group were more active and prefer to use virtual laboratory than traditional approach in the control group.

An effective learning condition to improve the higher order thinking skills of students is a simulation of scientific inquiry. The results of Younis' study (2017) show that students who simulate practical work on computers have a higher level of thinking skills achievement compared to practical work in chemistry real laboratories. The results of this study are also supported by Simon (2015) that higher order thinking skills can be trained, developed, and achieved in a virtual laboratory. Virtual laboratories provide the features that students need to do practical work, such as objectives, theory, 3D simulations, and questions about practicum activities (Darrah et al., 2014).

The data presented in Table 13 for higher order thinking skills also shows that the population means of EG-1 is also significant difference with EG-2. The difference between both of them is the presence or absence of a combination of the implementation of practical work, namely in the chemistry real laboratory by the demonstration methods and in the virtual laboratory based on s-SL. The students in EG-2 got a combination of practical work in chemistry real laboratory and virtual laboratory based on s-SL. Whereas, the implementation of practical work in the EG-1 was only carried out in virtual laboratory based on s-SL. Therefore, EG-2 gained as much practical experience as CG and EG-1. As a result, students' understanding in the EG-2 was higher than the other two groups. This results is proven by the means score posttest of EG-2 is the highest.

The results study of Nathaniel et al. (2016) also show that practical work in the combined laboratory (real and virtual) has a significant effect on the student learning achievements. The students in the EG-2 can monitor the changes at the sub-microscopic level that cannot be seen when practical work in the real laboratory, so that the two conditions complement each other to achieve students' higher order thinking skills. The students who gained direct experience to do practical work in chemistry real laboratory and virtual laboratory as supplement, will get achievement higher than the students who do practical work in the one of type laboratory (Solikhin et al., 2019b).

The mean score posttest of HOTS also as shown in the Table 14 also interpreted that the implementation virtual laboratory based on s-SL can be used as an alternative to giving a solution to the all of problems in real chemistry laboratory. This is proven by the mean score posttest of EG-1 is higher than CG. Additionally, the implementation virtual laboratory based on s-SL can also be used a supplement or complement to the chemistry real laboratory. It was proven by the mean score posttest of EG-2 is the highest. Previous study also support this finding. Virtual laboratory can be alternative or supplement to the real chemistry laboratory (Dominguez et al., 2018; Latifah et al., 2018; Tatli & Ayas, 2013).

### Conclusion

Based on the purpose of this study, it can be concluded that the population means of students' HOTS in the CG, EG-1, and EG-2 are significant difference. Virtual laboratory based on s-SL has effect 0.230 to the students' higher order thinking skills. It means that virtual laboratory has enough effect to improving the students' higher order thinking skills. Virtual laboratory based on s-SL can be used as an alternative to giving a solution to the all of problems in real chemistry laboratory. Additionally, the implementation virtual laboratory based on s-SL can also be used a supplement or complement to the chemistry real laboratory.

### Recommendations

There are two recommendations from this study. First, chemistry teacher or practitioners can use virtual laboratory based on s-SL to solve the problems in chemistry real laboratory like as the absence of chemical and/or instruments, no chemistry real laboratory but there is a computer laboratory, no laboratory assistant, and the limited of time allocation in the one of topic. Second, the next experimenter can apply the virtual laboratory based on s-SL to know the effect of its to science process skills. The experimenter can also add activity base as feature to save the activities of user as long as in the virtual laboratory based on s-SL. The experimenter can also add online feature to create collaborative and communication skills.

### Limitations

As preliminary research, this study was only conducted in one of the 3T Regions in Indonesia. As a long as implementation process of the s-SL in public general senior secondary school in 3T Regions, the experimenter can not control the other variables that can affect students' higher order thinking skills.

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