COMPUTER ASSISTED SIMULATION TO INCREASE THE CHEMISTRY ACHIEVEMENT OF PUPILS IN SENIOR HIGH SCHOOL

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ABSTRACT

Many technology applications developed to for teaching Chemistry in labs and classrooms. With a Research and Development Model of ADDIE (Analysis-Design-Develop -Implement-Evaluate), this study was carried out in Senior High School (SHS) in Padang Sidimpuan Municipal of North Sumatra, Indonesia. Thus, data were collected by using observation sheet, questionnaire, test and documentation. Samples were chosen by purposive sampling i.e 3 chemistry teachers and learners in class XI-Science-IPA as many as 86 people from 3 public senior high schools (SHS) Padang Sidimpuan. Obtained data were processed for analyzing the process of learning Chemistry through Computer Assisted Simulation on the Inquiry basis. The learning achievement in the cognitive domain after using the inquiry-based in computer-assisted learning model, computer-assisted laboratory and simulation increased. The learning achievement in cognitive domain in public senior high schools (SHS) 2, 5, & 7 Padang Sidimpuan grew. The result of the study was found obtained value =0.74, which fall into high category. With the Computer Assisted Simulations and lab works, the motivation and achievement of pupils in Senior High School increased.

Keywords: Computer assisted simulation, lab work, chemistry, learning achievement

INTRODUCTION

The application of technology such as Computer Assisted Simulation with the Inquiry basis for teaching Natural Sciences now plays an important role. The Chemistry teaching process with a Computer Assisted Simulation plays an important role. Two things related to inseparable chemistry, namely chemistry as a product (Cooper and Nicola, 2015) (chemical knowledge in the form of facts, concepts, principles, laws, and theories, findings of scientists and chemists as a process of scientific work (Mulyasa, 2008). Pratiwi et al (2015) found memorization in classroom learning and less thinking process. Naaman (2012) argued that he laboratory activities can facilitate for cognitive, affective, and psychomotor achievement. Furthermore, the results of research conducted by Hofstein & Naaman (2007) stated that the activities in the laboratory can provide an opportunity for learners to learn in an authentic environment and can build their knowledge of chemical-related phenomena.

The Preliminary study results in February-March 2016 revealed that the manual laboratory contained in the chemical package has less opportunity for learners to develop process skills, because the learners fully follow only the steps listed in the laboratory manual. The results of the preliminary survey which was conducted by the authors on 6 to 20 April 2015 showed that 51.11% of teachers only once –twice Lab Work in year. For more details are presented in Figure 1.

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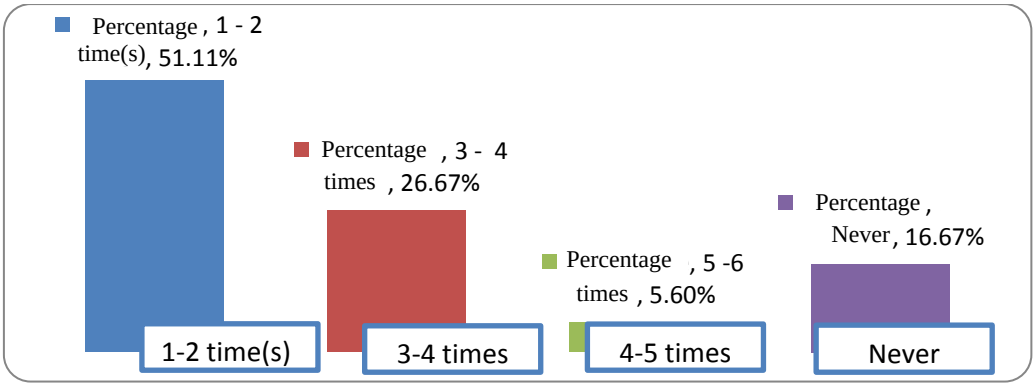

Fig. 1. Implementation of Chemical Lab Works in Public High School Padang Sidimpuan

Based on Figure 1, it shows that high school chemistry teachers in Padang Sidimpuan Municipal of North Sumatra still rarely carry out Lab Work activities to help learners understand the concept of the material presented. Pitafi & Farooq (2012) included the scientific attitudes, such curiosity, rationality, critical thinking, showed the improvement of learners' scientific attitudes, besides using learning model can also be assisted by using instructional media such as computer assisted simulations.

The use of the computer assisted simulation with inquiry chemical basis trains pupils to observe directly through practical activities. The simulation results that already were provided by computer-assisted expend some skills. The computer-based multimedia as a means of simulation to train certain skills and competencies, included; a multimedia display in the form of animation that allows learners in the science majors to experiment without having to be in the laboratory (Rusman, 2012).

THEORETICAL REVIEWS

This Research and Development Model of ADDIE (Analysis-Design-Develop -Implement-Evaluate) adopted some theories; Computer Assisted Simulations and Inquiry-based learning (Caswell & LaBrie, 2017) for developing learners' cognitive.

Computer Assisted

Computer-assisted instruction (CAI) programs are considered to make the learning outcomes of students. However, little is known on the schools who implement such programs as well as on the effectiveness of similar ICT-programs (Oz & Jafar, 2015); CAI uses the computers as an interactive instructional technique whereby a computer is used to present the instructional materials and monitor the learning that take place. A combination of text, graphics (animation), sound and video in the learning process was found. Forrie (Furo, 2015) argued the CAI is available online which enhances the teachers' instruction in several ways. The application of computer program is supported by theories of constructivism and social constructivism (Omari 2015). Schwienhorst (in Balushi, 2012) found CAI makes students have experiment and participated in learning. The improvement in science performance by the experimental group resulted from the application of CAL in science lessons and that the instructional methods used by teachers influence the performance of the learners (Samuel in Nduati, 2012). Teaching approach may affect students' achievement, and therefore use of an appropriate teaching approach is critical to the successful teaching and learning of science (Wambugu and Changeiywo in Nduati, 2012)..

The poor understanding of the basic concepts which has to be visualized mentally in Chemistry lesson needs the Computer Assisted Teaching and Learning (CATL) method.

Though a large number of computer applications are available, the use of PowerPoint presentation, animation, audio, video and multimedia presentations are worth mentioning (Barathy, 2015).

Inquiry Based Learning in Chemistry Lesson

Inquiry based learning for chemistry is a new technique, besides it is not merely oriented to the learning outcomes alone, but also it requires a quality learning process (Duran & Dokme, 2016). Implementation of inquiry-based learning model in laboratory activities makes the learners got involved in the process of formulating problems, formulating hypotheses, designing experiments, collecting and analyzing data and drawing conclusions scientifically. Thus, the guided inquiry provides more direction for learners who are not ready to solve problems with inquiry without assistance due to lack of experience and knowledge or not yet reached the level of development cognitive required abstract Gormally & Brickma (2011). Teachers have the provided guidance and direction to learners to conduct investigation activities. The guided inquiry learning model steps consist of: 1) presenting the phenomenon; 2) problem formulation, hypothesis, collecting data, testing hypotheses and formulating conclusions (Pratiwi et all 2015). Uzezi & Zainab (2017) were using laboratory investigation methods with guided inquiry with the steps include: 1) providing problems related to the experiment to be performed; 2) to find solutions to problems, learners have sought information about the experimental process; 3) the group has decided the experimental process based on the information they find.

Moreover, Mamlook & Naaman (2011) included some experimental activating in Chemistry lab. Sanjaya (2008) found the guided inquiry model effects. Khan et all (2011) reported a guided inquiry learning model improved learner achievement in Chemistry.

RESEARCH METHODOLOGY

The Research and Development (Pandit et all, 2011) was applied in the Computer Assisted Simulation with Inquiry based in Chemistry lesson at Senior High Schools in Padang Sidimpuan Municipal of Indonesia. The integration of disciplines and the collaboration of roles are indispensable requirements (Yoshikawa, 2012) with Analysis-Design-Develop-Implement-Evaluate (Almomen et all, 2016) was done; (1) **Analysis**; analysis is conducted to determine the development objectives and for whom the development of this instructional model is addressed. The analysis activities undertaken in this research are focused on: a) curriculum analysis; b) analysis of learner characteristics; c) teacher analysis. (2) **Design:** the learning model includes: a) designing learning syntax, i.e learning steps that will be carried out using inquiry-based chemistry learning model and computer-assisted simulation; b) designing the social system, namely the description of the role and relationship of teachers with learners and the rules underlying it; c) The principle of reaction, describes how teachers should guide, construct information, and respond to what the learners do in the learning process; d) Support systems, all facilities, materials, tools, learning environments, and learning tools needed to implement the learning model; e) designing instructional and companion impacts. The design of this learning model will be packaged in guidebooks for teachers and learner books. (3) **Development:** to test the validity of the developed model. In order to obtain the results of the development of inquiry-based chemistry learning model, laboratory and computer simulation to improve the achievement of good learner learning, researchers conducted validation steps developed in order to improve the weaknesses that still exist. (4) **Implementation:** the test was administered in three Public High Schools; SHS 2, 5 and & 7 Padang Sidimpuan. The effectiveness of products developed in this study by measuring the achievement of learning in the realm of cognitive, psychomotor and affective. The effectiveness of the use of developed learning models was measured by using quasi-

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experimental designs.(5) **Evaluation** ; to review the advantages and disadvantages of chemical learning model developed based on the stage that has been done.

Table 1. Research Design of One Group Pre-test Post-test

Group	*Pre-test*	*Treatment*	*Post-test*
Treatment Class	T_1	Xb	T_2

The population in this study included all Public High School in Padang Sidimpuan Municipal of North Sumatra consisting of 8 (eight) Public High schools. For the test subjects were chemistry teachers who taught in class 11^{th} and grade 11^{th} of Science learners. Selection of test subjects conducted with Purposive Sampling was the selection of samples with certain criteria. The criteria used in selecting the sample as a test subject are schools with high, medium and low learners' ability. Based on the above criteria, the sample used in this study learner in class 11^{th} Science of Senior High School (SHS) 2 Padang Sidimpuan got High category; SHS 5 in medium category and SHS 7 Padang Sidimpuan in low category.

Hypothesis testing was to see the effectiveness of the Inquiry-Based Chemistry Learning Model, Computer Assisted Laboratory and Simulation through a quasi-type experiment with the Pretest-Posttest Control Group Design pattern, it should be followed by hypothesis testing using t test. To test the hypothesis in order to test the effectiveness of Chemical Learning Model of Mercury, Computer-assisted Laboratories and Simulation by using t test, the first test is normality test with *Kolmogorov Smirnov* Test (Razali & Wah, 2011) and *homogeneity* test is *Levene's* Test (Nordstoke & Bruno, 2010) with SPSS version 21.00 program. Independent sample t test (independent sample t test) is used for limited test, while the test is extended by paired t test. Furthermore, Friedman's nonparametric test to measure the outcomes of psychomotor and affective learners' learning achievement in the expanded test.

RESEARCH RESULT

Curriculum analysis

To support the results of curriculum analysis through the syllabus, then in this stage of the analysis is also carried out the distribution of questionnaires to the chemistry teachers in Senior High School (SHS) 2 Padang Sidimpuan, SHS 5 Padang Sidimpuan and SHS 7 Padang Sidimpuan. The results of the questionnaire dispersion analysis are summarized in Table 2.

Table 2. Analysis of Lab Work Potential of Chemistry Learning Material Class 11th Odd Semester

Learning materials	Potential Lab Work	Availability of Tools and Materials	
		Tool	Material
Hydrocarbons	0%	0%	0%
Crude oil	0%	0%	0%
Thermochemistry	100%	100%	100%
Reaction rate	100%	100%	100%
Chemical equilibrium	100%	100%	100%

From Table 2 above it can be seen that almost all the chemistry material of class 11th semester odd can be done through Lab Work activities, except on Hydrocarbon and Petroleum materials. In this step the researchers also conducted a literature study to find out the main concepts that learners learn and arrange them schematically in concept maps presented in teacher handbooks and learner handbooks.

Analysis of Learner Characteristics

Characteristic analysis of learners in the development of inquiry-based chemistry, computer lab and computer simulation model through semester test results on chemistry subjects in 2015/2016 and learners' interest in chemistry subjects include: attention, willingness, pleasure, and liveliness shown in Table 3.

Table 3. Description of Chemistry Learner Interest in Public High School Class 11th in Academic year 2015/2016

No	School	Aspect Observed			
		Attention	Willingness	Pleasure	Liveliness
1.	SHS 2 Padang Sidimpuan	72, 14	68,28	72,71	62,50
2.	SHS 5 Padang Sidimpuan	67,05	61,65	62,88	58,81
3.	SHS 7 Padang Sidimpuan	66,79	69,53	69,06	68,59
Average Score		53,02	66,64	70,24	62,25
Category		Less	Enough	Good	Enough

The results of questionnaire analysis in Table 3 shows that in the learning process of chemistry in some schools during this time looks less attractive, so that learners got bored and have less willingness in following the subjects of chemistry especially pay attention to teachers in teaching, so the classroom atmosphere tends to passive, it is very little learners who prepare to follow chemistry subjects, conduct discussion activities to work on problems related to chemicals and even still rarely learners who want to deepen the chemistry material taught in school by looking for information from other sources.

Analysis of Chemistry Teaching Techniques

The process of chemistry learning conducted by teachers in Public High School Padang Sidimpuan was probed by questionnaires. The results of the analysis are shown in Table 4.

Table 4. Description of Chemistry Learning Process of High School Learners Class 11th in Academic year 2016/2017.

No	School	Aspects observed		
		Use of Methods or Teaching Strategies	Utilization of Learning Resources and Learning Media	Assessment
1.	SHS 2 Padang Sidimpuan	61,54	54,08	44,69
2.	SHS 5 Padang Sidimpuan	63,75	64,01	50,21
3.	SHS 7 Padang Sidimpuan	61,54	54,08	44,69

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Average Score	62,28	57,39	46,53
Category	Enough	Less	Very bad
1.	Feasibility of Content	96,67	Very Valid
2.	Language Feasibility	98,86	Very Valid
3.	Graph	98,21	Very Valid
	Average	97,91	Very Valid

To measure the improvement of learner achievement in the cognitive domain using gain score formula. Description of data of learning achievement of cognitive domain from both groups that is experiment group and control group is presented in Table 5.

Table 5. Data Description Outcomes of Learning Achievement Cognitive Sphere

No	Information	Experiment Class (11^{th} Science)		Control Class (11^{th} Science 2)	
		Pre-test	**Post-test**	**Pre-test**	**Post-test**
1.	Lowest Score	25	75	30	65
2.	Higher Score	55	95	55	85
3.	Mean	44,09	82,73	45	73,86
4.	Standard Deviation	9,34	5,92	6,36	6,71
3.	Gain score	0,68		0,52	

To test the hypothesis in order to test the effectiveness of Learning Model developed by using t test, first tested the requirements of normality test and homogeneity test presented in Table 6.

Table 6. Summary of Normality Test Achievement Cognitive Sphere

Data	Asymp.Sig (2-tailed)	Status
Pretest (Control Class)	0,06	Normal
Pretest (Experiment Class)	0,20	Normal
Postest (Control Class)	0,16	Normal
Postest (Experiment Class)	0,07	Normal

Based on Table 6, it can be seen that in the experimental group obtained Asymp value Sig (2-tailed) for pre-test of 0.20 and post-test of 0.07 While in the control group obtained Asymp value. Sig (2-tailed) for pre-test of 0.06 and post-test of 0.16, then the data in both groups are normally distributed because the data in both groups has Asymp. Sig (2-tailed) is greater than the 0.05 significance level (5%). Homogeneity test is used to know the sample comes from a homogeneous population or not by comparing the two variants. Levene's Test was used for the value of significance (p)> 0.05; then the data comes from a homogeneous population, but if the value of significance (p) <0.05 then the data comes from a non homogeneous population.

Table 7. Homogeneity Test of Learning Achievement of Cognitive Sphere

Data	Significance	Status
Pre-test (Control and Experiment Class)	0,290	Homogeneous
Post-test (Control and Experiment Class)	0,674	Homogeneous

In order to know the effectiveness learning model developed by t test has been fulfilled, then tested the hypothesis using independent sample t test (independent sample t test) with equal variances assumed. The results of the t-test analysis to test the truth that learner learning achievements in the cognitive domain using inquiry-based, computer-assisted and computer-assisted learning models were higher than those using conventional learning models. This test showed the results of pre-test and post-test. The hypothesis of this study using statistical formula as follows:

Ho: The achievements of learner learning in the cognitive domain using inquiry-based, in computer-assisted, computer-assisted and simulated learning models are greater than or equal to those using conventional learning models.

Ha: The achievement of learner learning in the cognitive domain using inquiry-based, in computer-assisted learning model and computer-assisted simulations is higher than that using conventional learning.

If $P \geq 0.05$ then Ho is accepted and Ha is rejected. If $P < 0.05$ then Ho is rejected and Ha accepted. Here the result of hypothesis testing on learner achievement in cognitive domain by using t test presented in Table 8.

Table 8. Hypothesis Testing Using Test t

Class	The average gain normalized	Df	T_{count}	t_{table}	Significance
Experiment (11th-science 3)	0,52	42	4,527	2,018	0,000
Control 11th Science 2)	0,68				

Criteria for hypothesis testing that is if $t_{count} \leq t_{table}$ then H0 accepted while if $t_{count} > t_{table}$ then Ha accepted. Based on the data Table 4:20, with significance 0.000 smaller than 0.05 and obtained $t_{count} > t_{table}$ (4.527 > 2.018), then Ha accepted, it means that Learner learning achievement in the cognitive domain using inquiry-based chemistry learning model, laboratory and computer-aided simulation is higher from those using conventional learning. This suggests that inquiry-based, computer-assisted learning models and computer-assisted simulations are more effectively used in improving learner learning outcomes in the cognitive domain than in control groups using conventional learning models. Learning process is basically the process of interaction, both the interaction between learners and learner interaction with teachers, even the interaction between learners and the environment. The Improved Achievement of learner learning in the psychomotor realm with an average value of 0.35 or increased with the category of being. For more details are presented in Figure 2.

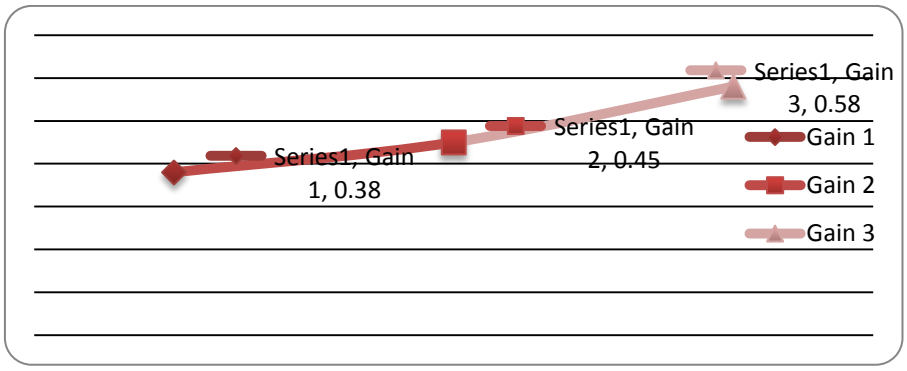

Figure 2. Increased Achievement of Psychomotor Learning

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Assessment of learner achievement in psychomotor domain by using performance appraisal can be elaborated into its indicator component which consists of: ability to prepare Lab Work activity, activity process of implementation of inquiry-based laboratory and activity of delivery of experiment result. The result of data analysis about learning achievement indicator in psychomotor domain can be described in graph as shown in Figure 3.

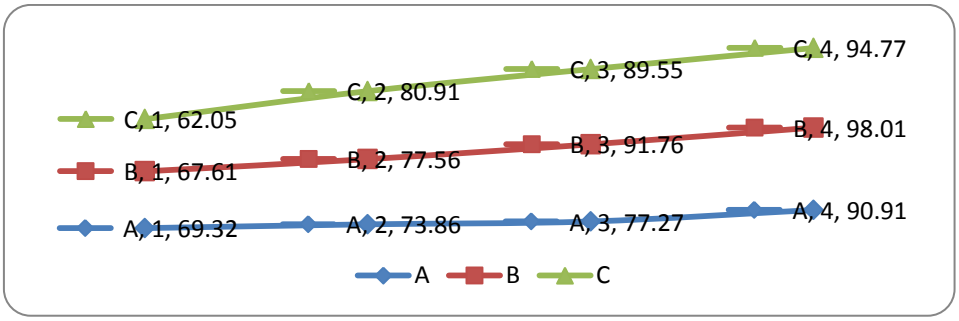

Figure 3. Results Analysis of Learning Achievement Indicators in the psychomotor domain

Information:

1 = Lab Work I
2 = Lab Work II
3 = Lab Work III
4 = Lab Work IV

A = Ability to Prepare Lab Work Activities
B = Activity Process Implementation Lab Work based on inquiry
C = Submission of Experiment Result

CONCLUSIONS

It concluded that the effective computer-based, inner-chemistry learning model and computer simulations:

This result indicates that Ha is accepted, meaning that there are differences in learning achievement in the cognitive domain before and after using inquiry-based, in computer-assisted learning model, computer-assisted laboratory and simulation supported made the increase of achievement in cognitive domain. Increase in SHS 2 Padang Sidimpuan of 0.74 high category; SHS 5 obtained 0.67 medium one. The improvement of learner achievement in the psychomotor and affective domain in each Lab Work of learning materials Thermochemistry, Reaction Rate and Chemical Equilibrium using Friedman test obtained values less than 0.000 significance, it means that there are differences in learning achievement in the psychomotor and affective domain before and after using the model of learning chemistry-based inquiry, laboratory and computer-assisted simulations.

The increase value was gained in the psychomotor domain. The value gained from lab work I to II were 0.12 (low category) and gained from Lab Work II to lab work III of 0.27 (low category) with a mean value was 0.20 and it went to a low category, which means there was an increase in learner achievement gain achievement in the psychomotor realm, but still low category. Meanwhile, the psychomotor domain gain value in SHS 5 Padang Sidimpuan from Lab Work I to practice II is 0.24 (low category) and gain from Lab Work II to lab work III is 0,51 (medium category) with average gain value is 0.38 category medium. The increase of achievement of learners in the affective domain in SHS 5 Padang Sidimpuan with value was 0.69; it was medium category and value obtained 0.46 was in the medium category and average gained value = 0.58 was still fall into the medium category.

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