USING VIRTUAL LABORATORY IN DIRECT INSTRUCTION TO ENHANCE STUDENTS' ACHIEVEMENT

Zulqifli Alqadri
Mr, Universitas Pendidikan Indonesia, INDONESIA, zulqifli.alqadri@student.upi.edu

Abstract

Chemistry laboratory is a place where students can learn and construct their knowledge through experiment-based learning. However, the reality shows that some schools are unable to facilitate their students with adequate laboratorie equipments. Therefore, virtual laboratory is present as an alternative media which is very cheap, safe, effective and efficient in in virtually conducting chemistry experiments. This study aims to investigate the effectiveness of the use of chemistry virtual laboratory in direct instruction model, as a frequently used learning model, to enhance students' achievement on colligative properties of solution topic. Direct instruction model is a learning model which emphasizes on the declarative and procedural knowledge consisting of five phases: orientation, presentation or demonstration, highly structured practice, guided practice, and independent practice phases, where the use of virtual laboratory can be implemented in the guided practice phase. This Pre-Experiment Research used One Group Pre-test and Post Test Design where both consist of 20 items multiple choice. The participants in this study were the grade XII science students in one of the senior high schools in Bulukumba Regency, South-Sulawesi Province, Indonesia. Subject were 30 students consist of 10 males and 20 females in the first half of the academic year. Data were obtained from 20 items achievement test in multiple choice, either from pre-test or post-test. There are three criteria of effectiveness that must be met to investigate the effectiveness of virtual laboratory in direct instruction, these are: the score of students is at least 75 (minimum completeness criteria of chemistry subject is 75), classical completeness is at least 80 %, and Normalized-gain (N-gain) is at least in the medium category. The results of data analysis showed that the mean score of students pre-test and post-test were 42.5 and 81.33 respectively. There were 25 students who have the score above or equal to 75 so that classical completeness reached 83.33%. The average of Gain is 38.83 and N-gain value obtained was 0.69 and it is in the medium category. These findings show that all the results of data analysis meet the criteria of effectiveness mentioned above. In other words, virtual laboratory is effectively used in direct instruction to enhance students' achievement.

Keywords: Virtual Laboratory, Direct Instruction, Students' Achievement

1 INTRODUCTION

Chemistry is a science that is used as the basis for development and can be applied in other disciplines. Therefore it is often referred as the core of science. The characteristics of chemistry according to Kean & Cathrine (1985), are: a) most of the object of study is micro; b) sequentially and growing quickly; c) not just solving problems; and d) the substance/material studied in chemistry very much. Almost all topics in chemistry is an experimental subjects that can be applied in the laboratory (Chang, 2005). The laboratory is

one of the most important element in the chemistry learning process, especially for the experiment-oriented topic. Laboratory is a place where students learn and build their knowledges (Tatli & Ayas, 2010). In addition, laboratory is also used as a place to apply the theory, research and scientific development. However, the learning process in the laboratory also has some disadvantages, such as: activity in the laboratory has a very big risk because students are using tools and hazardous chemicals; the use of relatively expensive equipments in experiment; requires a lot of time in preparing and conducting experiments; and lack of laboratory equipments, or inadequate laboratory conditions limiting teacher to guide students in conducting experiments (Tuysuz, 2010).

Based on the interview with chemistry teachers in Bulukumba Regency South-Sulawesi Province, Indonesia, indicates that some schools do not have a complete science laboratory and the lack of laboratory use in learning. Another fact revealed that the intensity of laboratory use for learning chemistry is still very low while almost all topics in chemistry that should be taught by experimental methods in the laboratory. One of the problems they faced is inadequate of science laboratory facilities which effects to the experiment activities not allowed to be carried out properly. Students do not gain experience in building their knowledge through experiments in the laboratory so they can not understand the concept in depth, especially for topic colligative properties of solutions, so it can affects to the students' achievement. Based on these problems, we need an interactive learning media which is practical, very cheap, effective, efficient and allows students to conduct safely experiments.

The rapid development of information and communication technology also has an impact on the development of instructional media through electronic technology. Learning-based Virtual Laboratory is a superior product and the laboratory advances in information technology (Salam, Setiawan, & Hamidah, 2010). Virtual Laboratory is a computer-based learning media that shows environments and processes of experiments, students perform experiments using virtual laboratory as if they in the real laboratory (Harahap, 2010). According to research Tatli & Ayas (2013), the use of virtual laboratory for learning chemistry showed the nearly similar results with learning in the real laboratory. Virtual lab-based learning can increase student mastery of concepts (Salam, Setiawan, & Hamidah, 2010). While the research conducted by Tuysuz (2010) revealed that the use of virtual labs gives a positive effect on attitudes and student learning outcomes when compared with conventional learning. The direct instructional model has certain stages of learning that are highly correlated with declarative and procedural knowledge (Setiawan, Fitrajaya & Mardiyanti, 2010). Declarative knowledge is knowledge of factual information that can be delivered orally or in writing, while procedural knowledge is knowledge of a person's ability to do things in accordance with the procedure. Virtual laboratory is one of the alternative media to apply declarative and procedural knowledge in the form of a virtual lab if the real experiment is not possible.

Based on the description above, the aim of the study is to investigate the effectiveness of the use of chemistry virtual laboratory in the direct instruction model to enhance students' achievement on colligative properties of solution topic. Harjanto (2003) revealed that the effectiveness of learning outcomes can be evaluated from the number of students who achieved the entire learning objectives which expressed in percent within the predetermined time. The effectiveness of the learning process can be determined through the evaluation of learning. Evaluation of effectiveness measurement can be conducted by the test, reflection, contemplation and supported by the teacher's record data (Jauhar, 2011).

1.1 Virtual Laboratory

The rapidly development of information and communication technology initiates the development of computer-based instructional media. Computer technology is an invention that will stimulate students to learn so that learning will be more optimal (Rusman, 2012). Computer roles in supporting learning and training as an extra helper in the study known as the Computer-Assisted Instruction (CAI) (Arsyad, 2013). One of the product of computer-based learning media is virtual laboratory. Virtual Laboratory has fulfill the six criteria as an effective learning media. The effectiveness criteria of media consist of: (a) Ease of navigation, which means student can easily use the program; (b) The content of cognition; (c) Knowledge and presentation informations; (d) Media integrates aspects and skills that must be learned; (e) Have a look artistic; (f) The program should provide the desired learning by students (Thorn, 1995).

Simulation using computer will open up the opportunity for student to learn in a dynamic, interactive, and self-styled environments to resemble actual/real (Arsyad, 2013). According to Ariani & Haryanto (2010), virtual laboratory will make student as if they conducting experiment based on the phenomenon that occurs in the real laboratory. In addition, Keller & Keller (2005), also revealed that virtual laboratory is simpler laboratory experience than real laboratory so it makes easier for students to analyze data and make conclusions. Tatli & Ayas (2012) revealed that virtual laboratory is at least as effective as the real laboratory

and a positive influence on constructivist learning environment of students. Herga, Grmek & Dinevski, (2014) also suggested that virtual laboratory is very effective use in learning because it is able to present visualization effect compared to conventional learning. Student who use virtual laboratory has ability to recognize laboratory equipment almost similar with students' ability in the real laboratory (Tatli, Z. & Ayas, 2013). While the research of Tuysuz (2010) showed that virtual laboratory have the positive effect on students' achievements and attitudes of students in learning chemistry. Virtual laboratory is not a major laboratory instructional media, but it is only as an alternative option if the experiment process is not possible to be conducted (Tatli & Ayas, 2010).

1.2 Direct Instruction

Direct instruction model is a learning model associated with declarative and procedural knowledges that is achieved sequentially and step by step (Suhana, 2014). Direct instruction model is appropriate when used on topics that have highly structured and purposeful learning objectives (Nur, 2008). According to Moore (2006), direct instruction consist of five phases, these are orientation, presentation or demonstration, highly structured practice, guided practice, and independent practice phases. Furthermore Joyce, Weil, & Calhoun (2000) revealed the roles of students and teacher in direct instruction are shown in Table 1.

Table 1. Five Phases in Direct Instruction

Phase	Students Roles	Teacher Roles
Phase 1 Orientation	• Listens • Asks question that demonstrate connections to prior knowledge or previous lessons	• Clarifies objectives and procedures for the new learnig task • Activates prior knowledge • Connects to previous lessons
Phase 2 Presentation or Demonstration	• Asks questions that demonstrate understanding of concept, skill, or strategy • Provides examples of concept, skill or strategy	• Explains, demonstrates and gives examples of concept, skill, or strategy • Uses a visual presentation of the material • Prompts students to provide examples of concept
Phase 3 Highly Structured Practice	• Practices with teacher support	• Leads students through step-by-step practice using examples • Uses visuals of practice examples
Phase 4 Guided Practice	• Practice under the close guidance of teacher	• Monitors and provides corrective feedback
Phase 5 Independent Practice	• Practice completely on own	• Provides feedback and encouragement • Feedback may be delayed

1.3 Students' Achievement

Learning is a process that effect in a change of behavior by assimilation or accommodation to new experiences. According to Rusman (2012) learning is the interaction process for all situations that exist around individual students which is directed to the achievement of objectives and processes through a variety of experiences that created by teacher. Behavioral changes that occur in the student referred to as a learning outcomes. Furthermore, students' achievement is a number of student gained experience that includes three aspects: cognitive, affective, and psychomotor. Students' achievement can be measured using a valid assessment instrument. The results of the assessment will indicate the level of success of a learning program (Arikunto, 2013). According to Munadi (2008), there are several factors affect to the students' achievement, these are:

a. Internal Factors

   1) Physiological factors, including health conditions, physical condition, etc.

   2) Psychological factors, including intelligence (IQ), concerns, interests, talents, motives, motivation, cognitive and reasoning power of students.

b. External Factors

1) Environmental factors, including the physical environment and social environment. Natural environment such as temperature, humidity, and others.

2) Instrumental factors, including curriculum, facilities and teachers.

2 METHOD

The research method used Pre-Experiment with One Group Pre-test and Post Test Design. The participants in this study were the grade XII science students in one of the senior high schools in Bulukumba Regency, South-Sulawesi Province, Indonesia. Subject were 30 students consist of 10 males and 20 females in the first half of the academic year. The study consisted of three stages, including preparation, implementation, and evaluation. The first activity in the preparation stage was the interview with senior high school chemistry teachers in Bulukumba Regency, South-Sulawesi Province, Indonesia about learning process in the classroom and laboratory, and also students learning outcomes. Furthermore, colligative properties of solutions determined as the main topic then provided relevant virtual laboratory applications. Virtual Laboratory Software used is software that can be downloaded freely. The softwares were produced by Sullivan (2012) from Chemistry Department University of Oregon and UO Libraries Interactive Media Group. Figure 1 below shows one of the virtual laboratory software about Colligative Properties of Solution:

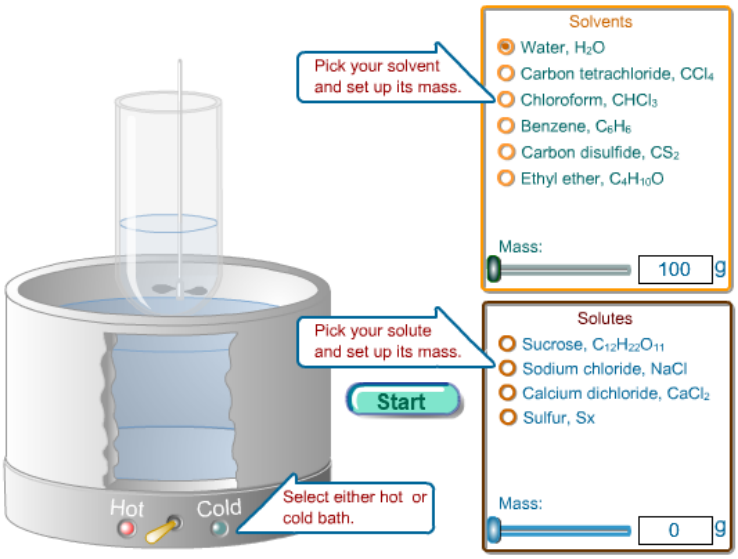

Fig. 1. Initial Interface of Virtual Laboratory Software

Another activity in the preparation stage was developing and validating a lesson plan, students' worksheets, pre-test and post-test instruments of students' achievement test. The implementation stage was learning process in the classroom which there are 5 meetings (1 meeting for pre-test, 3 meetings for learning process, and 1 meeting for post-test). Firstly, 20 pre-test items in multiple choice were administered to students in the colligative properties of solutions topic. Then students were studying using relevant virtual laboratory softwares in the direct instruction model. Generally, the learning process in this study used five stages of Direct Instruction model that can be shown in the Table 2.

Table 2. Learning Process The Use of Virtual Laboratory in Direct Instruction

Phase	Students Roles	Teacher Roles
Phase 1 Orientation	• Listened to the stated learning objectives • Explored curiosity through teacher questions	• Delivered learning objectives of Colligative Properties of Solutin topic (consist of 12 objectives) • Asked a question about topic to stimulate students' curiosity
Phase 2 Presentation or Demonstration	• Asked questions about the concept, skill, or strategy of topic which the teacher has presented or demonstrated.	• Explains, demonstrates and gives examples of concept, skill, or strategy about the topic of Colligative Properties of Solution

	• Provided examples of concept, skill or strategy about Colligative Properties of Solution toic	• Uses a visual presentation of the material • Asked students to provide examples of concept about Colligative Properties of Solution topic
Phase 3 Highly Structured Practice	• Practiced with teacher support to solve the problem through step-by-step practice	• Provided problems for students to complete about the topic
Phase 4 Guided Practice	• Conducted experiments using Virtual Chemistry Laboratory through students worksheet	• Facilitated students to conduct experiments using the Virtual Chemistry Laboratory provided corrective feedback
Phase 5 Independent Practice	• Answered questions on worksheets and discussed experiment results using Virtual Chemistry Laboratory	• Provided feedback and encouragement at the end of the discussion

Final stage of this study was the evaluation of the results of learning, where 20 items achievement test in multiple choice were administered to students (post-test).

Students' achievement data were analyzed using descriptive analysis techniques. This descriptive analysis was used to describe the characteristics of distribution of students' achievement scores by using virtual laboratory softwares in direct instruction. In this study, the effectiveness of the use of virtual laboratory in direct instruction to enhance students' achievement was analyzed based on particular criteria. The criteria is adapted from Depdikbud (in Trianto, 2010). The use of virtual laboratory in direct instrucion is effective to enhance students' achievement if:

a) The score of students is at least 75

The individual score of students must be more than or equal to the minimum completeness criteria of chemistry subject (MCC/KKM ≥ 75). The minimum completeness criteria of chemistry subject is shown in the Table 3.

Table 3. Minimum Completeness Criteria of Chemistry Subject (MCC/KKM)

Score	Individual Completeness
< 75	Incomplete
75 – 100	Complete

Note: MCC/KKM score could be different in every school or region in Indonesia

b) Classical completeness is at least 80%

Classical completeness can be calculated by the following formula:

$$CC = \frac{\sum CS}{N} \times 100\%$$

CC = Percentage of classical completeness
$\sum CS$ = Number of students who completed
N = Number of whole students

c) Normalized-gain (N-gain) is at least in the medium category

Normalized-gain (N-gain) can be calculated using the following equation (Hake, 1999):

$$\text{N-gain} = \frac{\text{Post-test Score} - \text{Pre-test Score}}{\text{Maximum Score} - \text{Pre-test Score}}$$

The category of N-gain is shown in the Table 4.

Table 4. Interpretation of N-gain Score

N-gain Score	Category
N-gain ≥ 0.7	High
0,7 > N-gain ≥ 0.3	Medium
N-gain < 0.3	Low

3 RESULTS AND DISCUSSION

The design of this study is a pre-experiment and using One Group Pre-test Post-test Study which aims to investigate the effectiveness of the use of Virtual Chemistry Laboratory in Direct Learning to enhance students' achievement as. Direct Instruction model emphasizes the learning of declarative and procedural knowledge in a structured and gradual manner. The use of virtual laboratory media in the direct instruction model was in the fourth phase, Guided Practice Phase. Because this phase is requires an active involvement of students in applying knowledge and skills that they have been known although they are still monitored by the teacher. The first step before the learning process begins, then it has done pre-test to the students. It aims to obtain an initial score that is used as a comparison of the final score (post-test). In addition, pre-test results serve as a benchmark of progress after implementing a learning program. Post-test is carried out at the end of direct instruction process using Virtual Laboratory. Based on the results of the study, table 5 below presents the data obtained from the pre-test and post-test of students:

Table 5. The Results of Students Pre-Test & Post-Test

Variables	Pre-Test	Post-Test
Total Students	30	30
Ideal Score	100	100
Highest Student Score	65	100
Lowest Student Score	10	65
Mean	42.5	81.33
Standard Deviation	11.58	8.50

Table 5 shows that from 20 items about the pre-test administered to the students, the highest score achieved by students is 65 and the lowest score is 10. The mean obtained was 42.5. The mean score is still very low when compared with the score of minimum completeness criteria of the chemistry subject, that is 75. It is concluded that the students' knowledge on colligative properties of solution topic is fairly low. Therefore, the process of direct instruction using virtual laboratory is expected to improve students' achievement. The student's post-test score shows a significant improvement. The highest score of students on the post-test is 100 and the lowest score achieved by the student is 65. The mean post-test score is 81.33 or up by 38.83 from mean pre-test. The increase in mean from pre-test to post-test significantly indicates that the use of virtual laboratory in direct instruction can enhance students' achievement.

The topic of Colligative Properties of Solution consists of 12 learning objectives whic divided into two basic competencies with a minimum completeness criteria of 75. Students who have post-test score less than 75 then declared as incomplete. Meanwhile, students are declared complete if they have a post-test score of 75 or more. It can be analyzed that students who achieved the complete criteria have a good knowledge of the topic Colligative Properties of Solution because they have score above criteria. Thus, it can be concluded that these students' achievement can not be separated from the role of the implementation of vitual laboratory in learning process. Classical completeness aims to calculate the percentage of how many students are in the category of complete or have a score above 75. The following table 6 shows the results of the analysis of classical completeness:

Tabel 6. Classical Completeness

No	Category		Frequency of Students	Percentage
1	Incomplete	< 75	5	16.67 %
2	Complete	≥ 75	25	83.33 %
Total			30	100 %

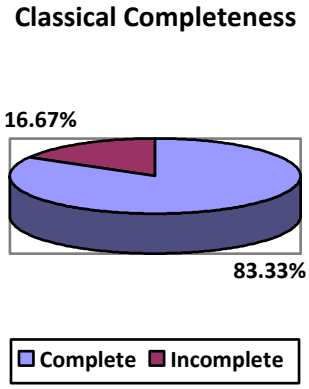

Fig. 2. Chart of Classical Completeness

Table 6 and figure 2 above revealed that out of 30 students, there are 25 students in the complete category with the percentage of 83.33%, and the other in the incomplete category. Thus, classical completeness can be achieved because it exceeds the required percentage of 80%. Another criteria of the effectiveness is about Normalized-gain (N-gain) where it is at least in the medium category. N-gain is used to analyze the difference between pre-test and post-test scores or to analyze students' achievement after implementing direct instruction using virtual laboratory. N-gain analysis results are presented in Table 7 below:

Table 7. N-gain of Implementation Virtual Laboratory in Direct Instruction

Variables	Gain	N-Gain	Interpretation
Total Students	30	30	**Medium**
Maximum Difference	60	1.00	
Minimal Difference	25	0.50	
Standard Deviation	6.11	0.11	
Mean	38.83	0.69	

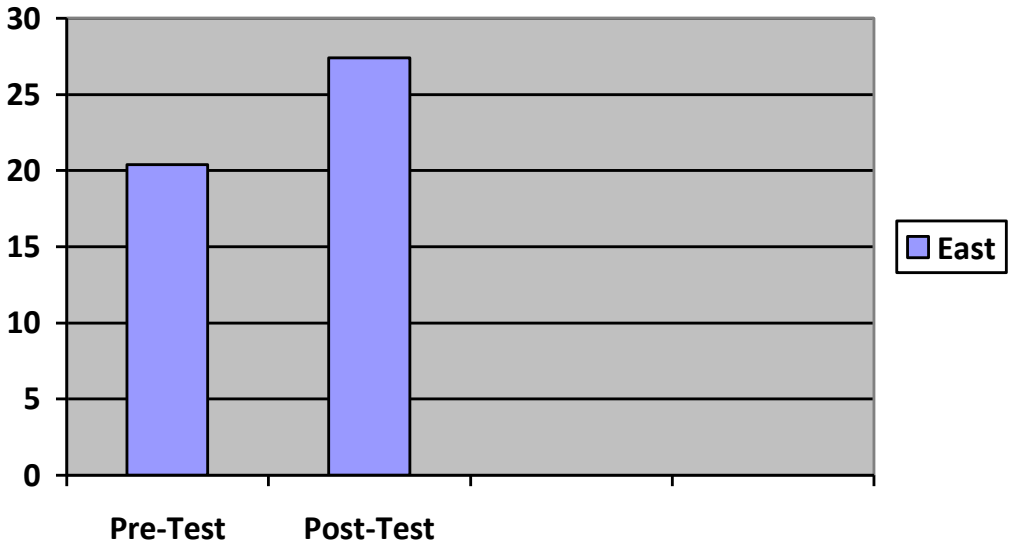

Fig. 3. Chart of Mean between Pre-Test and Post-Test

The data above provide information that there is an increase in average student score significantly from 42.5 to 81.33. So the average gain becomes 38.83. After the calculation using the formula, then the N-gain is 0.69. Based on interpretation table of N-gain value, it is in medium category. This indicates that the effectiveness criteria of N-gain (at least medium category) can be achieved. Based on the three reviews of effectiveness criteria above, all the results of the data analysis indicate that virtual laboratory is effectively used in direct learning because all the conditions are met.

4 CONCLUSION

The effectiveness criteria of using virtual laboratory in direct instruction can be analyzed from three perspectives, these are:

a) The score of students is at least 75
b) Classical completeness is at least 80%
c) Normalized-gain (N-gain) is at least in the medium category

Based on the results of data analysis on the study of the effectiveness of the use of virtual laboratory on direct instruction to enhance students' achievement, all the results of data analysis meet the criteria of effectiveness mentioned above. In other words, virtual laboratory is effectively used in direct instruction to enhance students' achievement.

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