USING VIRTUAL LABORATORY IN DIRECT INSTRUCTION TO ENHANCE STUDENTS' ACHIEVEMENT

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Abstract

Experiment-based learning is a quite effective learning method to study chemistry. Thus chemistry laboratory is extremely needed in the learning process since it is used as a place where students learn and build their knowledge by applying theory, research and scientific development. However, chemistry experiments have some limitations in the real laboratory, such as students using hazardous and relatively expensive tools and chemicals and it takes more time to prepare and conduct experiments. One of the most suitable media to overcome some problems in the real laboratory is using virtual laboratory. The virtual-based experiment, as an advanced technology product, is quite cheap, safe, effective and efficient alternative media. This study aims to investigate the effectiveness of chemistry virtual laboratory in direct instruction model to enhance student's achievement on colligative properties of solution topic. Direct instruction model emphasizes on the declarative and procedural knowledge. It consist of five phases: orientation, presentation or demonstration, highly structured practice, guided practice, and independent practice phases, where in this study the virtual laboratory was implemented in the guided practice phase. This Pre-Experiment Research used One Group Pre-test and Post Test Design where both consist of 20 multiple choice items. 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. The subject were 30 students consisted of 10 males and 20 females in the first half of the academic year. Data were obtained using 20 multiple choice items of achievement test, either from pre-test or post-test. Three criteria of the effectiveness must be fulfilled to investigate the effectiveness of virtual laboratory in direct instruction, there 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 indicated that the mean of students' pre-test and post-test were 42.5 and 81.33 respectively. There were 25 students who got scoe above or equal to 75 so that classical completeness achieved 83.33%. The average of Gain was 38.83 and N-gain was 0.69, so it was in the medium category. Eventually all the results of data analysis met the criteria of effectiveness mentioned above. In other words, virtual laboratory is effectively used in direct instruction to enhance students' achievement on colligative properties of solution topic.

Keywords: Virtual Laboratory, Direct Instruction, Students' Achievement

1 INTRODUCTION

Chemistry is the core of natural sciences. The characteristics of chemistry according to Kean & Cathrine (1985), consist of: a) the object of chemistry is abstract; b) it is sequentially and rapidly developing; c) it is

more than just solving the problems; d) it provides many concepts to learn. Almost all topics in chemistry are experiment-based concepts (Chang, 2005). Therefore, experiment-based learning is a quite effective learning method in learning chemistry. Thus chemistry laboratory is extremely needed in the learning process since it is used as a place where students learn and build their knowledge by applying theory, research and scientific development (Tatli & Ayas, 2010). However, chemistry experiments have some limitations in the real laboratory, such as students using hazardous and relatively expensive tools and chemicals and it takes more time to preparing and conducting experiments (Tuysuz, 2010).

One of the most suitable media to overcome some problems in the real laboratory is using virtual laboratory. The virtual-based experiment, as a superior program of technological and information development, is an advanced technology product (Salam, Setiawan, & Hamidah, 2010). Virtual Laboratory is not only a computer-based experiment that shows experiment environment and process but also students can conduct experiments as if they in the real laboratory (Harahap, 2010). The virtual laboratory is highly recommended program for school if their students are not possible conducting experiments for several reasons.

There are some senior high schools in Bulukumba facing the limitations of the real laboratory. Based on the interview with several chemistry teachers in Bulukumba Regency South-Sulawesi Province, Indonesia, revealed that almost half of grade XII students failed to achieve the Minimum Completeness Criteria of Chemistry Subject (MCC/KKM) on the midterm exam for chemistry, especially on colligative properties of solution topic. It is due to students never conduct experiment on that topic since their chemistry laboratory is inadequate. Consequently, students' learning experience by experiments in the laboratory is quite lacked and can not understand the topic in depth. Therefore, virtual chemistry laboratory is extremely needed in that case as a practical, quite cheap, effective, and efficient interactive program and also it allows student to conduct experiments safely.

There are some studies indicate that virtual laboratory can enhance student's academic achievement. According to Tatli & Ayas (2013), student's learning outcome is not significant between using virtual chemistry laboratory and the real laboratory. Virtual laboratory-based learning can increase student mastery of concepts (Gunhaart & Srisawasdi, 2012; Salam et al., 2010). Where student's learning outcome with virtual laboratory is higher than student with the common learning experience in case of matter mastery (N. Herga & Dinevski, 2012). While Tuysuz (2010) revealed that using virtual laboratory gives a positive effect on attitudes and student learning outcome when it compared to conventional learning. Furthermore, Taşkin & Kandemir (2010) revealed that computer-based learning enhancing student's learning outcome and skill.

Based on the research findings of virtual laboratory, using virtual laboratory in direct instruction, as the frequently learning model in senior high schools in Bulukumba, still has not been revealed. Direct instruction model has certain stages of learning and it is highly correlated with declarative and procedural knowledge (Setiawan, Fitrajaya, & Mardiyanti, 2010). So the aim of the study is to investigate the effectiveness of the use of chemistry virtual laboratory in direct instruction model to enhance students' achievement on colligative properties of solution topic.

1.1 Virtual Laboratory

Computer-based instructional media is highly advanced along with the development in information and communication technology. The computer is an invention in technology that stimulating students to learn (Rusman, 2012). Computer roles in supporting learning and training as an extra media in learning known as the Computer-Assisted Instruction (CAI) (Arsyad, 2013). Virtual laboratory is one of the computer-based learning media. Virtual Laboratory has met the six criteria as an effective learning media. The effectiveness criteria of media consist of: (a) Ease of navigation means student 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) Looking 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 (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) revealed that virtual laboratory is simpler laboratory experience than the real laboratory and making students easier to analyze data and also making conclusions. Virtual laboratory is at least as effective as the real laboratory and gives students a positive influence on constructivist learning environment (Tatli & Ayas, 2012). Furthermore, virtual laboratory is very effective to be used in learning because it is able to present visualization effect compared to conventional learning (Herga, Grmek, & Dinevski, 2014). Student has the ability to recognize laboratory equipments almost similar with student' ability in the real laboratory (Tatli & Ayas, 2013). While Tuysuz (2010) revealed that virtual laboratory has the positive effect on students' achievements and attitudes of students in learning chemistry. It 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 Model

Direct instruction model is a learning model associated with declarative and procedural knowledge that can be achieved sequentially and step by step suhs (Suhana, 2014). Direct instruction model is quite precise when it comes to the highly structured topic and purposeful learning objectives (Nur, 2008). According to Moore (2006), direct instruction consist of five phases, there 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 in Table 1.

Table 1. Five Phases in Direct Instruction Model

Phase	Student Roles	Teacher Roles
Phase 1 Orientation	• Listen • Ask question that demonstrate connections to the prior knowledge or previous lessons	• Clarify the objectives and procedures for the new learning task • Activate prior knowledge • Connect to previous lessons
Phase 2 Presentation or Demonstration	• Ask questions that demonstrate understanding of concept, skill, or strategy • Provide examples of concept, skill or strategy	• Explain, demonstrate and give examples of concept, skill, or strategy • Use a visual presentation of the material • Prompt students to provide examples of concept
Phase 3 Highly Structured Practice	• Practice with teacher support	• Lead students through step-by-step practice using examples • Usesvisuals of practice examples
Phase 4 Guided Practice	• Practice under the close guidance of teacher	• Monitor and provides corrective feedback
Phase 5 Independent Practice	• Practice completely on their own	• Provide feedback and encouragement • Feedback may be delayed

1.3 Students' Achievement

Learning is the process of behavioral change by assimilation or accommodation to the new experiences. According to Rusman (2012) learning is the interaction process between students in all situations where teacher creates variety of experience to make students achieve the learning objectives. Student's behavioral changes referred as a learning outcomes. Furthermore, students' achievement is a number of student gaining experience on three aspects: cognitive, affective, and psychomotor. Students' achievement can be measured using a valid assessment instrument. The results of the assessment indicated the level of achievement of a learning program (Arikunto, 2013). According to Munadi (2008), there are several factors affect to the students' achievement, there are:

a. Internal Factors

   1) Physiological factors: health and physical condition, etc.

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

b. External Factors

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

   2) Instrumental factors: curriculum, facilities and teachers.

2 RESEARCH METHOD

The research method of this study 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, there are preparation, implementation, and evaluation. The first step in the preparation stage was the interview with senior high school chemistry teachers in Bulukumba Regency, South-Sulawesi Province, Indonesia about instructional model, chemistry laboratory, and students' achievement in chemistry midterm exam. Furthermore, colligative properties of solutions determined as the topic since almost half of students failed to achieve Minimum Completeness Criteria of Chemistry Subject (MCC/KKM). Thereafter provided relevant virtual laboratory applications 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:

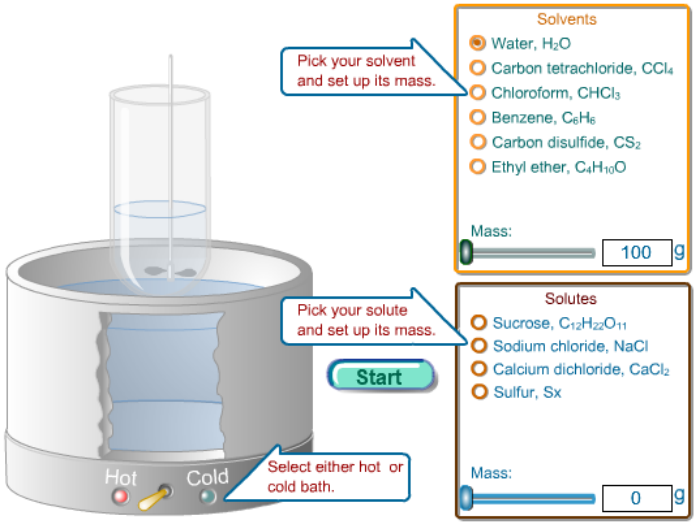

Fig. 1. Initial Interface of Virtual Laboratory Software

The next step in the preparation stage was developed and validated the lesson plan, worksheets, pre-test and post-test instruments of student's achievement test. The implementation stage was learning process in the classroom which consisted of 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 experimented using the virtual laboratory softwares in direct instruction model. Generally, the learning process in this study used five stages of Direct Instruction model as 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. • Provided examples of concept, skill or strategy about Colligative Properties of Solution topic	• Explained, demonstrated and gave examples of concept, skill, or strategy about the topic of Colligative Properties of Solution • Used 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 by using Virtual Chemistry Laboratory as on the worksheets	• Facilitated students to conduct virtually experiments and provided corrective feedback
Phase 5 Independent Practice	• Answered questions on worksheets and discussed the virtually experiment results	• Provided feedback and encouragement at the end of the discussion

The final stage was the evaluation of the learning program. There were 20 items of achievement test in multiple choice that had been administered to the students (post-test).

Student's achievement data was analyzed using descriptive analysis techniques. This descriptive analysis used to describe the characteristic of students' achievement scores distribution. In this study, the effectiveness of using 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 virtual laboratory in direct instrucion is effective to enhance students' achievement if it meets the criteria:

a) The score of students is at least 75

The individual score of student 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 student 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 FINDINGS AND DISCUSSION

The design of this study is a pre-experiment with One Group Pre-test Post-test Study. It aims to investigate the effectiveness of the use of virtual chemistry laboratory in direct instruction to enhance student's achievement. Direct Instruction model emphasizes the learning of declarative and procedural knowledge in a structured and gradual manner. In this study, virtual chemistry laboratory was applied in the guided practice phase of direct instruction model. The guided practice phase required an active involvement of students to apply their knowledge and skills although they are still monitored by the teacher. The first step before the learning process was administered the pre-test to the students. It aimed to obtain student's initial score and used as a comparison with the final score (post-test). In addition, pre-test results served as a benchmark of progress after learning program had been implemented. The Post-test is carried out at the end of the learning program using Virtual Laboratory. Based on the results of the study, table 5 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 out of 20 pre-test items, the highest score that can be achieved by student was 65 and the lowest score was 10. So the mean of the score obtained was 42.5. The mean score was very low when compared with the score of minimum completeness criteria of the chemistry subject (score 75). So It was referred that the students' knowledge on colligative properties of solution topic is fairly low. Therefore, the learning model program of direct instruction using virtual laboratory was expected to improve students' achievement. The student's post-test score indicated the significant improvement. The highest score on the post-test was 100 and the lowest score was 65. The mean of post-test score was 81.33 or up by 38.83 from the mean of pre-test. The significantly mean enhancement from the pre-test to post-test indicated 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 which divided into two basic competencies and its minimum completeness criteria is 75. Student who got post-test score less than 75 then declared as incomplete. Meanwhile, student was declared complete if he got 75 or more of the post-test score. So it can be analyzed that student who achieved the complete criteria has quite good knowledge about colligative properties of solution topic. Thus, it can be revealed that the implementation of vitual laboratory in learning process affect the student's completeness. The classical completeness aimed to calculate the percentage of how many students are in the category of complete or got score 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 %

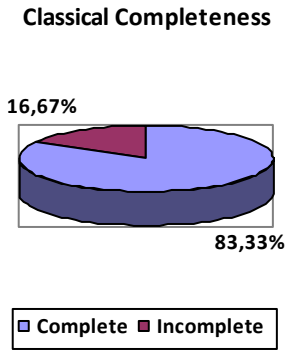

Fig. 2. Chart of Classical Completeness

Table 6 and figure 2 above revealed that out of 30 students, there were 25 students in the complete category or 83.33%, and the others in the incomplete category. Thus, classical completeness can be achieved because it exceeds of 80% the required percentage. Another criteria of the effectiveness is about Normalized-gain (N-gain) must be in the medium category. N-gain was used to analyze the difference between pre-test and post-test score or to analyze students' achievement after virtual laboratory in direct instruction had implemented. 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	

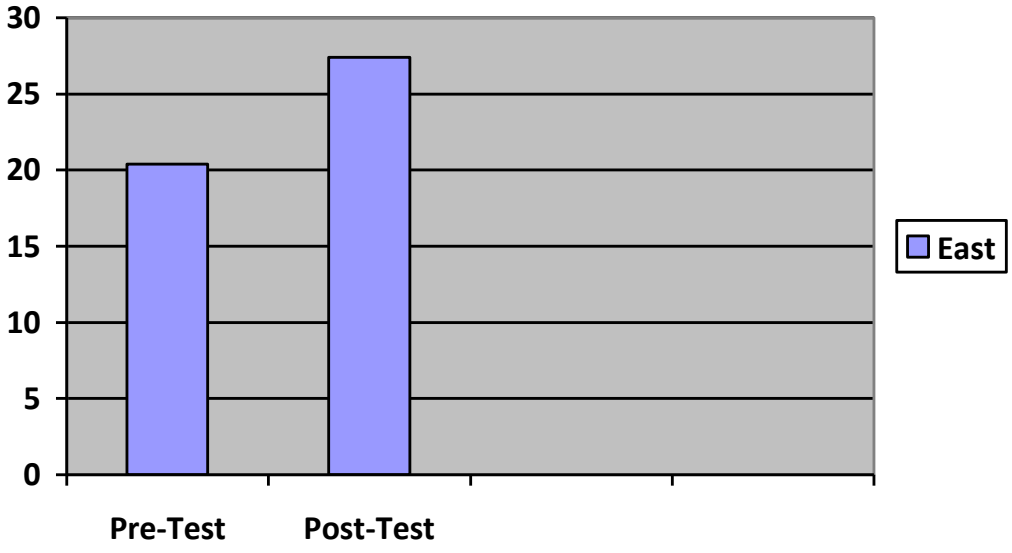

Fig. 3. Chart of Mean between Pre-Test and Post-Test

The data above provided information about the significantly enhancement of students' score from 42.5 to

81.33. So the average of gain became 38.83. After calculated on the formula, the N-gain is 0.69. Based on the interpretation of N-gain score, the N-gain was in the medium category. It indicated that the effectiveness criteria of N-gain (at least medium category) was achieved. Therefore, the results in this study met the three criteria of effectiveness.

4 CONCLUSION

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

a) The score of student is at least 75

b) Classical completeness is at least 80%

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

Eventually all the results of data analysis met the criteria of effectiveness mentioned above. In other words, virtual laboratory is effectively used in direct instruction to enhance students' achievement on colligative properties of solution topic.

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