Optimizing students’ scientific communication skills through higher order thinking virtual laboratory (HOTVL)

S Sapriadil1, A Setiawan1, A Suhandi1, A Malik1,2, D Safitri1,3, S A S Lisdiani1 and N Hermita4

1 Sekolah Pascasarjana, Universitas Pendidikan Indonesia, Bandung, Indonesia
2 Program Pendidikan Fisika, UIN Sunan Gunung Djati, Bandung, Indonesia
3 SMAN 2 Kota Sukabumi, Sukabumi, Indonesia
4 Program Studi PGSD FKIP, Universitas Riau, Pekanbaru, Indonesia

*Corresponding author’s e-mail address: sapriadil@student.upi.edu

Abstract. Communication skill is one skill that is very needed in this 21st century. Preparing and teaching this skill in teaching physics is relatively important. The focus of this research is to optimizing of students’ scientific communication skills after the applied higher order thinking virtual laboratory (HOTVL) on topic electric circuit. This research then employed experimental study particularly posttest-only control group design. The subject in this research involved thirty senior high school students which were taken using purposive sampling. A sample of seventy (70) students participated in the research. An equivalent number of thirty five (35) students were assigned to the control and experimental group. The results of this study found that students using higher order thinking virtual laboratory (HOTVL) in laboratory activities had higher scientific communication skills than students who used the verification virtual lab.

1. Introduction

In various different countries, science educator had explicitly identified communication skill as the competence needed for science literacy ability in 21st century [1]. In the effort to face the challenge in 21st century, it is important for all individuals to possess that communication skill [2]. Indonesian government had implemented real step in preparing students to face the challenge in 21st century by making new policy about curriculum. Curriculum 2013 announced refer to skill of 21st century which is oriented to higher order thinking skill, among other is communication skill. Therefore, learning process which has been done in school should be able to develop students’ communication skill. Physics is one science subject taught in school, and it is expected to become tool in training and equipping communication skill for students. Based on explanation about the goal of physics subject in Senior High School level, it shows that physics subject teaching in Senior High School is aimed to train and develop students’ thinking and communication skill in order that students can master physics concept and principle and to develop their knowledge [3].

Communication skill is skill in delivering or sharing the ideas about knowledge which had been acquired [4]. Communication ability also defined as ability in delivering and giving information and speaking and writing ability [5]. Communication skill comprise oral, written and nonverbal communication skill. In physics, scientific communication skill comprise some indicators, namely: (1) identify ability in obtaining information; (2) able to state daily event in physics language or symbol; (3)
contribute idea in group work; and (4) explain the physics idea and task in product/report making; and (5) communicate the result of product or work/report [6]. Communication skill focused on six higher order learning skill i.e. information retrieval, scientific reading, listening and observing, scientific writing, information representation, and knowledge presentation. Each higher order skill consist of skill and sub special skill [7].

This research will focus on students’ scientific communication skill in scientific writing, information representation and knowledge presentation. Some researches mentioned that in developing students’ communication skill, it can be done through laboratory activity [8], because learning through laboratory activity play important thing in developing students’ communication skill [9]. It is confirmed by Zezekwa’s statement that through practicum activity can train and develop students’ soft skill and hard skill [10]. The earlier research stated that inquiry based-practicum can develop students’ communication skill [11]. But the condition of laboratory activity today still not as expected. Some earlier researches showed that 1) the practicum done in school had been managed effectively; 2) the type of experiment practiced is too simple and not meaningful; 3) in practicum activity, students are only required to report the result of observation, but rarely they are asked to analyze interconnection among variables observed, to test the prediction, or to choose some possible explanations toward study result; 4) practicum activity which is very structured and only as verification less awake students’ curiosity so it less develop creativity [9]. Therefore, this research will develop students’ scientific communication skill in the material of electric circuit through higher order thinking virtual laboratory (HOTVL) activity.

Higher order thinking laboratory (HOT Lab) is practicum activity which emphasize problem solving by using higher order thinking skill which consist of some processes, namely understanding the challenges, generating ideas, preparation for lab work, doing lab work, communicating and evaluating results [12]. HOT Lab design consisting of 11 phases of activities which include: real world problems; determine and evaluate ideas; experimental question; materials and equipment; prediction; question of the method; exploration; measurement; analysis; conclusion; and presentations [13]. However, the limitation of equipment in school and time often become obstacles in doing practicum [13]. The present of virtual lab become one solution for that problem [14]. Virtual lab is laboratory designed through computer program which is made as if like real laboratory [15]. Virtual lab can be web or application which enable students to conduct simulation experiment [16]. Virtual lab consists of web or application design that are possible to users (students) to operate the simulation experiment [17]. Moreover, virtual labs can also visualize the microscopic phenomena contained in electrical circuit concept. Learning by visualizing a microscopic phenomenon can help students to understand at concept [18]. Therefore, it is expected that application of higher order thinking virtual laboratory can optimizing students’ scientific communication skills on the material of electric circuit.

2. Methods
This research involved 35 students of experiment class and 35 students of control class from one of public school in West Bandung Regency. This research used quasi experiment method with posttest-only control group design [19] in class XII which was taken by purposive sampling. Experiment group was given treatment in the form of application of higher order thinking virtual laboratory (HOTVL) model whereas control group is given verification practicum activity. After given treatment, those two groups were given posttest.

Data collection was done by using multi-representation essay test and assessment sheet (non-test) for ability in making report and presenting knowledge orally as shown in Table 1. Information representation instrument is tested in the end of each session whereas assessment sheet is done during practicum activity process. The data score of scientific communication skills on aspects of the ability to scientific writing and knowledge presentation is obtained through the assessment sheet at each meeting shown in Table 2.
Table 1. Assessment of Scientific Communication Skills [6]

| Scientific Communication Skills          | Sub-Skills                                      | Type of Assessment |
|------------------------------------------|------------------------------------------------|--------------------|
| Scientific Writing                       | Make practicum report                           | Non Test           |
| Information                              | Make representation in the form of scheme, graph, mathematical and verbal | Test               |
| Representation                           |                                                  |                    |
| Knowledge presentation                   | Presentation material and Oral presentation     | Non Test           |

Table 2. An Example of Scientific Communication Skills Assessment Rubric

| Scientific Communication Skills | Aspect Scientific Communication Skills | Score |
|---------------------------------|----------------------------------------|-------|
| Scientific Writing              | 1. Make practicum report                | 1     |
|                                 | 2. Presentation material               | 2     |
| Knowledge presentation          | 3. Oral presentation                   | 3     |

3. Results and Discussion

Based on the observation of the practice using observation sheet to assess the communication skills of the students on the scientific writing aspect, information representation and knowledge presentation obtained data as shown in Figure 1.

Figure 1. Average scores of each aspect of scientific communication skills

The three aspects of scientific communication skills of scientific writing, information representation, and knowledge presentation in classes using HOTVL are higher than those in the lab implementation class. The information representation aspect shows the highest average score in the two group. The average score of the lowest scientific communication skills is in the scientific writing aspects either in the class using the HOTVL or the lab verification class.

Students use HOTVL of scientific communication skills on information representation aspects better than verification virtual lab. Aspects of information representation can be developed when students undertake activity of asking experimental questions, predicting, applying question method; exploring, measuring, analyzing, and concluding on the HOTVL. Students who verify the lab does not benefit the provision of science skills, hands-on and even minds-on skills [20].
The scientific writing aspect of students using HOTVL is better than students who use lab verification. The HOTVL provides an opportunity for students to apply learned concepts to solve problems encountered in everyday life. Students seek and select various sources of reference, discuss information obtained, determine and evaluate information relevant to the problem, create reports and present the results. It can be understood because the ability in presenting require basic ability in reasoning and argumentation which is quite good [21]. A student will be able to communicate a thing well, of course if she/he master the content well, understand cause-effect relation contained in that content and has good reasoning.

Based on analytic result of students’ scientific communication skill achievement in aspect of information representation in practicum activity on material of electric circuit, there is difference in achievement between experiment group and control group. The comparison on the aspect of information representation achievement is presented in the Figure 2.

![Figure 2. Average Score of achievement on the aspect of information representation](image)

Figure 2 shows that students tend to possess ability in representing knowledge into the form of scheme which is higher compared with their ability in representing it in the form of graph, verbal and mathematical. This tendency is influenced by some intelligence, habit and learning environment whereas the accuracy of multi representation is influenced by concept understanding, knowledge which is inculcated and exercise [22]. Each representation can help students in understanding keywords of a concept by identifying the representation presented. With keyword of a concept which had been acquired, students are able to make another representation in accord with the representation presented [23]. The ability in translating among representation modus in solving the problem is influenced by combination of representation, topic and students’ knowledge [24]. Besides, students’ ability in interpreting representation is influenced by being familiar with representation, familiar with the concept represented, student age and the way of thinking [25].

4. Conclusion

Based on study result, it can be concluded that application of higher order thinking virtual laboratory (HOTVL) design in laboratory activity the topic of electric circuit had higher scientific communication skills than students who used the verification virtual lab. Therefore, this design is feasible to be applied in laboratory activity another physics topic.
5. References

[1] Chung Y, Yoo J, Kim W, Lee H and Zeidler D L 2016 Enhancing students’ communication skills in the science classroom through socioscientific issues International Journal of Science and Mathematics Education 14 1–27

[2] Binkley M, Erstad O, Herman J, Raizen S, Ripley M, Miller-ricci M and Rumble M 2012 Defining Twenty-First Century Skills (New York: Springer)

[3] Depdiknas 2006 Pedoman Khusus Pengembangan Silabus dan Penilaian Mata Pelajaran Fisika (Depdiknas: Jakarta)

[4] Kivunja C 2015 Exploring the Pedagogical Meaning and Implications of the 4Cs “Super Skills” for the 21st Century through Bruner’s 5E Lenses of Knowledge Construction to Improve Pedagogies of the New Learning Paradigm Creative Education 6 2 224–239

[5] Mccroskey J C and Mccroskey L L 1988 Self-Report As An Approach To Measuring Communication Competence Communications Research Report 5 2

[6] Levy O S, Eylon B S and Scherz Z, 2008 Teaching communication skills in science: Tracing teacher change Teaching and Teacher Education 24 2 462–477

[7] Levy O S, Eylon B S and Scherz Z 2009 Teaching scientific communication skills in science studies: Does it make a difference? Int. J. Sci. Math. Educ. 7 5 875–903

[8] Rusilowati A and Khanafiyah S 2014 Implementation Of Open Inquiry Experimental Wave Model To Develop Physics Students Scientific Communication Skill Indonesian Journal of Physics Education 10 1 123–131

[9] Hofstein A and Lunetta V N 2004 The laboratory in science education: Foundations for the twenty-first century Science education 88 1 28-54

[10] Trivedi R and Sharma P M P 2013 A Study of Students’ Attitude towards Physics Practical at Senior Secondary Level International Journal of Scientific and Research Publications 3 8 3–6

[11] Aydn G 2016 Impacts of Inquiry-Based Laboratory Experiments on Prospective Teachers’ Communication Skills International Online Journal of Educational Sciences 8 38 49–61

[12] Malik A and Setiawan A 2016 The Development of Higher Order Thinking Laboratory to Improve Transferable Skills of Students Proceedings 2015 International Conference on Innovation in Engineering and Vocational Education 56 36–40

[13] Malik A, Setiawan A, Suhandi A and Permanasari A 2017 Enhancing pre-service physics teachers’ creative thinking skills through HOT Lab design AIP Conference Proceeding 1868 070001-1–070001-7

[14] Zacharia Z C and Constantinou C P 2008 Comparing the influence of physical and virtual manipulatives in the context of the Physics by Inquiry curriculum: The case of undergraduate students’ conceptual understanding of heat and temperature American Journal of Physics 76 4 425-430

[15] Zacharia Z C and Olympioudi G 2011 Physical versus virtual manipulative experimentation in physics learning Learning and Instruction 21 3 317–331

[16] Babateen H 2011 The role of Virtual Laboratories in Science Education 5th International Conference on Distance Learning and Education 12 100–104

[17] Bajpai M and Kumar A 2015 Effect of Virtual Laboratory on Students’ Conceptual Achievement in Physics International Journal of Current Research 7 2 12808-13

[18] Hermita N, Suhandi A, Syaodih E, Samsudin A, Isjoni J H, Rosa F, Setyaningsih R, Sapriadil and Safitri D 2017 Constructing and Implementing a Four Tier Test about Static Electricity to Diagnose Pre-service Elementary School Teacher’ Misconceptions Journal of Physics: Conference Series 895 1 012167

[19] Fraenkel J R, Wallen N E and Hyun H H 2012 How To Design and Evaluate Research in Education (8th ed.) (New York: McGraw-Hill)

[20] Heuvelen A V 1999 The workplace, student minds, and physics learning systems Journal American of Physics 69 11
[21] Kulgemeyer C 2018 Impact of Secondary Students’ Content Knowledge on Their Communication Skills in Science *International Journal of Science and Mathematics Education* **16** 1 89-108

[22] Kusumawati I, Marwoto P and Linuwih S 2015 Implementation multi representation and oral communication skills in Department of Physics Education on Elementary Physics II *AIP Conference Proceedings* **1677** 1 040017

[23] Rosengrant D, Heuvelen A, Van, and Etkina E, 2005 Case Study: Students’ Use of Multiple Representations in Problem Solving In Physics Education *Research Conference American Institute of Physics*

[24] Kohl P B, Rosengrant D and Finkelstein N D 2007 Strongly and weakly directed approaches to teaching multiple representation use in physics *Physical Review Special Topics-Physics Education Research* **3** 1 010108

[25] Ainsworth S 2008 *The Educational Value of Multiple-representations* 191–192 (University of Nottingham, UK: Springer)

**Acknowledgments**

The researcher would like to thank to physics teachers in SMAN 1 Cisarua, West Bandung Regency in helping the researcher to take and collect the data of students’ communication skill.