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Developing a Science Learning Devices Based on Susan Loucks-Horsley Model to Improve Scientific Literacy and Communication and Collaboration Skills

Asti D. Nurhayati[a], Jumadi[b*], Insih Wilujeng[c], Senam[d]

[a]*Student of Science Education Graduate Program, Yogyakarta State University, Indonesia*

[b,c,d]*Science Education Graduate Program, Yogyakarta State University, Indonesia*

[a]*Email: asti_dewinurhayati@yahoo.com*

[b]*Email: jumadi@uny.ac.id*

[c]*Email: insih@uny.ac.id*

[d]*Email: senam@uny.ac.id*

Abstract

This study aimed to: (1) develop a learning devices based on Susan Loucks Horsley (SLH) model for science learning in the 7th grade of the junior high school; and (2) investigate the effectiveness of the resulted devices to improve the scientific literacy and communication-collaboration skills. The method of the research was research and development (R & D) using modified Borg & Gall model [3]. The research conducted at a junior high school in Yogyakarta, Indonesia. Data were collected using assessment sheets, observation sheets, and tests. Data were analyzed with quantitative descriptive technique. The research results indicate that : (1) It have been obtained a learning devices based on Susan Loucks Horsley (SLH) model which is feasible for science learning in the 7th grade of the junior high schooh with predicate very good based on expert jugdment; (2) the resulted devices was effective to improve scientific lieracy and communication &collaboration skills.

Keywords: Susan Loucks-Horsley model; Scientific literacy; Communication & collaboration skills.

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* Corresponding author.

1. Introduction

In the efforts of adapting to current development, human relies on all aspects of life between science and technology and qualified human resources. In order to achieve the demand, Indonesia needs to revise its education curriculum to be able to compete in international level and to anticipate future's demand of 21st century learning. The problem is Indonesia got low score in PISA on scientific literacy compared to 63 other countries. It showed that the students' scientific literacy especially in science aspect is still very low. Curriculum revitalization was deemed necessary to gain better scientific literacy and therefore Curriculum 2013 (K-13) is implemented.

Scientific literacy is one of the several types of literacy such as written literacy, numerical literacy and digital literacy. In becoming scientifically literate, the student overcomes any fear of science. He or she is able to understand experiment and reasoning [1]. According to [11], scientific literacy is someone's ability to understand science, communicate science (written and orally), and implement science in solving problems so that he or she could have better attitude and awareness toward oneself and environment in making decisions based on scientific reasoning. Therefore, scientific literacy is knowledge needed to understand science-related public issues, communicate it (written and orally), implement it in the effort of solving problem based on scientific considerations toward technology and environment in order to comprehend an experiment and a reasoning.

The scientific literacy measurement by PISA [11] includes three dimensions, i.e. scientific content, scientific process, and scientific application context. Inthe scientific concepts dimension, a student should understand the key/essential concept in order to comprehend certain natural phenomena and the changes resulted from human activities. This is the big picture that helps explaining physical environment aspects. The literacy is measured by prompting questions that integrate concepts of physics, chemistry, and biology as well as earth and space science. Scientific literacy process measures a student's capability to use his or her scientific knowledge and understanding, such as finding, interpreting and evaluating evidence. The aspect process includes (1) recognizing scientific queries; (2) identifying evidence; (3) drawing conclusion; (4) communicating conclusion; and (5) demonstrating scientific concept understanding. The context of scientific literacy in PISA is more on daily life rather than class or laboratory settings. As in other literacies, the context includes important life issues in general as well as specific to individuals. The indicator that a student has good scientific literacy is he or she could do the test and get good result. The written test developed covers scientific content/concept aspects. The test is used to measure the students' learning outcome on content/knowledge area.

Besides improving scientific literacy, K-13 was developed to anticipate current development in accordance with the 21st century education needs. The skills needed require high order thinking skill, critical thinking, information technology mastery, as well as collaboration and communication skills. According to Kareulik and his colleagues (2013, p.129), the students' 21st century competence is divided into three, i.e. foundation knowledge (to know), meta knowledge (to act) and humanistic knowledge (to value). Therefore, a robust learning process is needed to achieve an optimum result. Such learning prepares the students not only memorizing information, but also acquiring competence needed in the 21st century – one of them is meta

knowledge. The skills in meta knowledge include problem solving and critical thinking, communication and collaboration, and creativity and innovation. However, the focus in on the students' communication and collaboration skills.

According to Nia (2014, p.71), there five characteristics for effective communication skills, i.e. (1) Openness, (2) Empathy, (3) Supportiveness, (4) Positiveness, and (5) Equality. The effective collaboration skills cover positive interdependence, face-to-face interaction in collaboration, individual responsibility in communal assignment, and interpersonal and small group collaboration skills [9].

The communication and collaboration skills are expected to prepare the students to communicate in various purposes clearly and effectively, either in speaking, writing, reading and listening. Besides, it also prepares the students to collaborate with others so the students could work effectively in groups, negotiate effectively in groups, and appreciate others in their groups (Yunus, 2014, p.9). From the observation done in SMP Muhammadiyah 2 Yogyakarta, it was found that the students' communication and collaboration skills were not maximal yet. To anticipate the problem, teachers should be able to employ the appropriate learning kit so that the students would have better communication and collaboration skills and could meet the expected output of the 21st century learning. Teachers should also accommodate the learning model and choose appropriate materials to develop the students' competence.

Learning in K-13 context is directed at meeting the demands of the 21st century learning which is to encourage students to seek out and not only receiving, so it is an active and constructive learning. It should be designed based on the contextual constructivist learning. It is expected that the students are accustomed to build their own knowledge based on real contexts that are meaningful to them. This scientific-based learning is the spirit of learning in K-13. In this study, the researchers used the new taxonomy of science education or commonly referred to as Susan Loucks-Horsley model with scientific approach.

Reference [2] states that the scientific approach is a dimension in scientific literacy for scientific investigations that push the students to be able to understand the approach for research. In scientific approach, the activities occur in the learning process are based on the theories of activity that include the achievement of personal domain, emphasizing intellectual and communication skills as well as the formation of attitudes or positive character, emphasizing on solving scientific problems through cooperative learning and socio-scientific decision making to improve scientific literacy or multidimensional scientific literacy [8]. Susan Loucks-Horsley model [10] is an extension of five domains (knowledge, science process skills, creativity, attitudinal, as well as the application and connection) in science education that does not just develop content and process. All of the domains are extension, development and deepening of Bloom's three domains to increase the activity of learning science in class, develop a positive attitude towards the subject, and achieve the overall assessment of learning outcomes that proportionate the students' cognitive, psychomotor, and affective. This model is also based on constructivist contextual approach; therefore, this model is suitable to be developed in learning process. A teacher in teaching should not only give the material in the textbooks to students. He or she should prepare in advance the subjects being taught and compile learning kit so that the objectives are achieved. Furthermore, it is in order that a teacheris ready to carry out the task of managing the classroom so that learning

can become interactive and motivating learners to participate actively. In the learning kit developed, in addition to being customized with the learning model applied, the material characteristics taken should also be in accordance with the model used in the study. Susan Loucks-Horsley model is more suitable for use in science materials related to environmental issues, where the students' knowledge acquired during the learning process can be used in their everyday life. The science material covered is global warming, which is closely related to the problems appeared in the surrounding environment. It is expected that with the knowledge, the students can be inspired to keep the surrounding environment for a safer and more comfortable earth as a wonderful place to live in as well as to minimize the effects of global warming that are harmful. Learning science should be packed in a special way considering its importance in achieving the goals of cognitive, affective, and psychomotor in which the science teacher should be able to organize the learning so that it is maximized and well-planned, generating the content knowledge required and a good attitude as a scientist [6]. Reference [5] state that ‘’…teaching science is not just about teaching a body of fact, skills, and processes but must also be about teaching the next generation to think about and reflect on the impact that science has our live, our work, and our society’’. Teaching science in junior high school students is intended that have high-level thinking skills. Teaching scienceis understood as a product, process, scientific attitude, applications in everyday life and creativity. The Integrated Science learning objectives are basically not much different with the ultimate goal of an integrated learning itself. The objectives are: improving the efficiency and effectiveness of learning, increasing interest and motivation, and achieving a number of core competencies at once. Through an integrated learning then students may have systematic thinking according to the steps of the scientific method, skills in conducting observations and experiments using tools to solve problems, as well as the necessary scientific attitude in solving problems[12]. Based on Dadan’s research (2009, p.269), it appears that in average the students in each domain get high average score. The cognitive test score is in the high category (73.11%); attitude score is in the category fairly good (58%); the process score is in the high category (63.31%); the application score is in the high category (61.93%); and the creativity score is still in low category (39.41%). The results provide direct positive and significant influence as well as indirect influencetoward cognitive, affective, process, application, and creativity variables. The picture proves that Susan Loucks-Horsley model has a significant impact on the improvement of the students’ knowledge aspect or scientific literacy. The development of the five domains is put in Susan Loucks-Horsley (SLH) model kit in four stages. The first stage is invited stage, i.e. demonstration or presentation of the phenomena. Explore and discover are the second stage, i.e. analysis and observations to answer their own questions associated with the demonstrations showed. In the third stage, purpose and explanation, the students prepare an explanation and resolution for their questions, and implement what they have learned. The last stage,i.e. taking action, gives an opportunity to students to find the usefulness of their findings and apply them in daily life [10]. Based on the mentioned problems, the researchers felt necessary to develop a science learning devices based on Susan Louks-Horsley model to improve the scientific literacy and communication & collaboration skills. The learning devices in this research consist of the syllaby, lesson plan and worksheet.

2. Method

The method of this research was research and development (R & D) using modified Borg & Gall model [3]. The procedure of the research consisted of 6 steps i.e. (1) initial stage, (2) research planning stage, (3) the first

development stage (product design and validation), (4) the second development stage (limited experiment), (5) the third development stage (field testing), and (6) the final product stage. The experiement (quasi experiment) using *pretest-postest control group design* as seen in table 1.

Table 1: Design of Experiment on Field Testing

Class	Pretest	Treatment	Posttest
Experiment	P1	T1	P2
Control	P1	T2	P2

Note:

P1 : pretest T1 : learning by using SLH based learning devices

P2 : posttest T2 : learning by using conventional learning devices

This research was conducted at Junior High School of Muhammadiyah 2 in Yogyakarta, Indonesia. The subjects participated in this study were 92 students of grade 7th which consisted of 29 students as limited try out class, 32 students as experiment class, and 32 students as control class. Instrument for data collection of the research can be seen in table 2. Validation of the instruments consisted of content validity by experts, and empirical validity by item analyse using Quest Program of Application. All of the instrument were stated as valid based on content validity by the expert judgment.

Table 2: Instruments for Data Collection of The Research

No	Variable	Data Sources	Instrument
1	Science Learning Devices based on Susan Loucks Horsley Model	product resulted (syllaby, lesson plan, worksheet)	assessment sheet
2	Communication and Collaboration skills	students	observation sheet
3	Scientific Literacy	students	test

The empirical validity for scientific literacy test using Quest Program resulted data : the number of the items were 30; 28 items had INFIT MNSQ value in the range of 0.77 to 1.30 so that it could be deduced that the items were valid. For item No. 4, the value obtained is less than 0.77, which means that the item was invalid; it was predicted because the test item was too easy so a revision was needed. For item no. 11, there was no INFIT MNSQ score because none of the students were able to answer that question; it was because the test item was too difficult for students. So for no. 4 and 11werereviseduntil they were valid. Based on the value of the item

difficulty which has diverse values between $-\infty$ to $+\infty$, it can be concluded that the tests was a good instrument. There are two kinds of data analysis i.e (1) product feasibility analysis, and (2) product effectivity analysis. Product feasibility analysis was conducted by categorizing the score of experts and practitioners assessment results based on normal curve division. The reliability of assessment was analysed using Borich's agreement [4]. Effectivity analysis of the learning devices in improving scientific literacy was conducted by categorizing the normalized-gain based on Hake categorization [7]. Effectivity analysis of the learning devices in fostering communication & collaboration skills was conducted by observing the development of communication & collaboration skills in three consecutive meeting.

3. Result and Discussion

3.1 Feasibility of the Products

Based on steps (1), (2), (3), and (4) in research procedure it was resulted the product i.e the science learning devices consisted of syllaby, lesson plan, and worksheets. The feasibility of the products and the realibility of assessment (percentage of agreement) is presented in **table 3**.

Table 3: Feasibility of the Products (syllaby, lesson plan, and worksheets)

Product	Experts (E)		Practitioners (P)		Average	Percentage of Agreement (%)		Category
	E1	E2	P1	P2		E	P	
Syllabus	3.91	3.82	3.73	3.82	3.82	98.84	98.81	very feasible
Lesson Plan	3.83	4.00	3.94	3.78	3.89	97.83	97.93	very feasible
Worksheet	3.71	3.86	3.71	3.57	3.71	98.02	98.08	very feasible

It seem from the **table 2**, that all the products are in very feasible category. The assessment has percentage of agreement between 97.93% to 98.84%. The product directly related to the students is worksheet, so it must be assessted by the students. The assessment of worksheet by the students on learning content aspect got average score of 3,27 with “good” category and its layout aspect got average score of 3.45 with “very good” category as presented in figure 1.

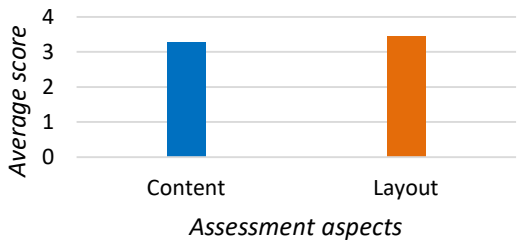

Figure 1: Histogram of worksheet assessment by the students

3.2 Scientific literacy improvement

The students' scientific literacy achievement in the field testing was measured using 30 items test which have validated through experts judment and empirical testing and revision from the previous stage and limited experiment stage. The data shown in Figure 2 describe that the average score of experiment class in pretest is 58.75 and 90.63 for posttest. The gain score in experiment group is 31.88 meanwhile the normalized-gain score is 0.77 with "high" improvement category. It proved that the improvement of the students' scientific literacy using learning devices based on SLH model is in "high" criteria. It also showed that the implementation of learning devices based on SLH model provided significant impact on the students' score improvement during the field testing. From the control group it could be seen that the average score for pretest is 52.28 and 74.16 for posttest. The gain score of the students' scientific literacy achievement is 21.58 with normalized-gain score of 0.46 and "average" category. It proved that the improvement of the students' scientific literacy using conventional learning devices is in "average" criteria.

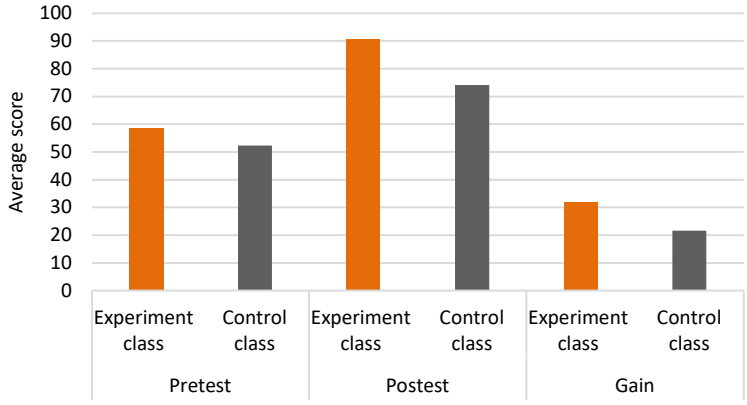

Figure 2: Pretest, Postest, and Gain of Students' Scientific Literacy

Based on the value of gain andnormalized gain, it could be concluded that the implementation of learning devices based on SLH model was more effective than the implementation of the conventional learning devices in improving students' scientific literacy. This result also can be proved from independent t-test, as seen from table 4. It could be seen that there are differences on posttest score between experiment and control class. The reason of doing posttest comparasion because there were not significant defferences pretest score between experiment and control class.

3.3 Acievement of Communication & Collaboration Skills

The communication and collaboration skills achievement aspects are measured using observation sheet to observe the students' skills during group discussions at each meeting which was developed by the researchers by considering the indicators of each aspect. Both aspects were observed in control and experiment groups. The result can be seen in figure 3.

Based on the figure, it could be seen that in control and experiment groups appeared average difference in each

meeting. It is shown in control class that there was a decrease in communication and collaboration aspects in the second meeting. In the experiment group, in each meeting there was an increase in each meeting. It showed that the students' communication and collaboration aspect could be improved in each meeting in the process implementing SLH model.

Table 4: The result of independent t-test of the posttest score

Test	Assumption	Levene's Test for Equality of Variances		T-test for Equality of Means						
		F	Sig.	T	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
posttest	Equal variances assumed	10,499	0,002	-6,830	61	0,000	-16,464	2,411	-21,284	-11,643
	Equal variances not assumed			-6,791	53,182	0,000	-16,464	2,424	-21,326	-11,601

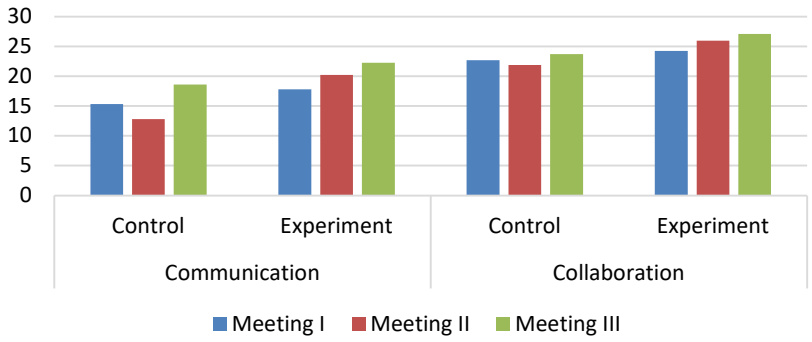

Figure 3: Histogram of Communication and Collaboration Skills Achievement

4. Conclusion

Based on the results of the discussion, it can be concluded that: (1) the science learning with Susan Loucks-Horsley model on the theme "Global Warming" which contains syllabus, lesson plan, student worksheets, and assessment instruments was valid to improve scientific literacy and foster the students' communication and collaboration skills aspects; (2) The science learning with Susan Loucks-Horsley model was effective to foster

the students' communication and collaboration skills aspects. It could be observed from that every meeting the average score of each aspect has increased. For meetings 1, the average result of the achievement of the communication aspect was 17.81 and of collaboration aspects was 24.25. For the second meeting, the average result of the achievement of the communication aspect was 20.22 and of collaboration aspects was 25.97. For the third meeting, the average results of the achievement of the communication aspect was 22.25 and of collaboration aspects was 27.06. The science learning kit based on Susan Loucks-Horsley model was effective to develop the students' scientific literacy. It was obvious from the average score the students' got in the pretest was 58.75 and in the posttest it became 90.63. The gain score got for scientific literacy achievement during field testing in the experiment group was 31.88 with the normalized gain score or 0.77. Besides, the Sig (2-tailed)0,000<0,05 in*Independent-Sample T-Test*showed that the learning implementing science learning kit based on Susan Loucks-Horsley model gave significant impact if compared with the control group.

5. Suggestion

Before conducting a research, the researcher was expected to provide teachers introduction on Susan Loucks-Horsley model in order to let them understand and therefore could implement the model in their classes.

The implementation of Susan Loucks-Horsley model in science learning is recommended to be used by schools and teachers and could be developed further in accordance with the condition and needs of the schools on other materials since meta knowledge debriefing especially the communication and collaboration skills need to be improved from younger age to be able to compete optimally in the 21st century competition.

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