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Development of Inquiry-Based Science Virtual Laboratory for Improving Student Thinking Skill of Junior High School

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Abstract

This research was conducted to produce inquiry-based science virtual laboratory that was eligible for developing students' thinking skills in science learning, and to determine the effectiveness of a virtual laboratory to develop students' thinking skills. It was Research and Development research using 4 D and Borg & Gall Model. There were 4 main phases (define, design, develop, disseminate) and additional phases (preliminary field testing, main product revision, main field testing, and operational product revision). The subject of this research were 7rd grade's students in junior high school. The instruments used included product validation questionnaire, observation sheet of thinking skill, and test. Validation and students' response data were analyzed descriptively; and the result of the test were analyzed by paired-t test. The results showed that the inquiry-based science virtual laboratory product was considered as excellent by expert and teacher and it was appropriate to use in science learning. Its effectiveness to increase students' thinking skills was showed by by significant value=0,000 from t-paired test.

Keywords: inquiry learning, science virtual laboratory, thinking skill

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INTRODUCTION

Information and knowledge is becoming as one of the things that can be produced, transferred, and consumed by the public, rapidly in this digital era. The acceleration of knowledge is supported by the application of media and digital technology called the information super highway. This is due to the advancement of information and communication technology, which gives an impact on education. The world of education is currently undergoing a massive transformation as a result of the digital revolution (Collins & Halverson, 2009). The technologies of information and communication also become an important part in learning, including science learning. As the digital era progresses, learning may be at once more individual (contoured to a person's own style, proclivities, and interests) yet more social (involving networking, group work, the wisdom of crowds, etc.)(Weigel, James, & Gardner, 2009).

At the same time, Indonesian education including science education are required to produce the Human Resources who have superior quality to face the global challenges of the 21st century. However, a major challenge is how to strive human resources of productive age, which is as much as 70% of the total population of Indonesia in 2020-2035, can be transformed into human resources who have the competence and skills through education so as not as a burden. Therefore, the world of education were important and required to ensure the students have learn and innovate skill, skills in using media and the technology of information, as well as be able to work, and survive by using their life skills, including thinking skills. Thinking skills are the set of basic and advanced skills and sub skills that governing mental processes of someone. These skills consist of knowledge, dispositions, and

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cognitive and meta cognitive operations (Vieira, Tenreiro-Vieira, & Martins, 2011).

Unfortunately, Indonesian students still have low ability of thinking skill. The research of Subali & Mariyam (2015) research was showed that the Indonesian Elementary Schools student's creativity still low. Students' science literacy is indicated low students' thinking skill. It can showed by the result of International comparative study of PISA (Programme for International Student Assesment) organized by OECD (Organization for Economic Cooperation and Development). PISA assesses the extent to which students who are getting near the end of their compulsory education "have acquired key knowledge and skills that are essential for full participation in modern societies". In 2009, The result of PISA showed that most of high school students (41%) have only limited knowledge of science, and can only apply it in general situations. None of them were able to consistently identify, explain, and apply scientific knowledge on a variety of complex life situations. From 72 participant countries, Indonesia ranks 62nd. In 2103, Indonesian students ranked the second lowest, 71st, worse than their ranking in 2009, when Indonesia ranked 57th. Indonesia's result in PISA's report is enhanced mean score 403, that shows some improvements in the skills of students (OECD, 2016).

PISA results show that Indonesia is still struggling. So, primary and secondary schools have to equip students with the analytical and critical thinking skills. They also have to inspire students become researchers in any field. Thinking skill of the Indonesian student must be improve for better life in the future of Indonesia.

Science is a field that always adjacent to the reality of student life. Through science education, students are expected to develop thinking skills trained in dealing with daily issues. Thinking skills are skills in combining the attitude, knowledge, and skill that enable a person to be able to form the environment in order to be more effective. Thinking skills are important to carry out the student face up the world because it is very tightly with some one's skill to manage information, such as: differentiating relevant and irrelevant information, organizing the facts, and attributing information. Students' thinking skills can be developed through education.

Education is currently undergoing a paradigm shift. Education originally defined as a conscious effort to encourage others to learn, now shifted combined with elements of entertainment or known as edutainment. Edutainment also can be called as e-learning. It is an active learning methods and practices is faster, more efficient and more entertaining. The idea is to combine the game by learning, using software or interactive learning (Rajendran, Veilumuthu, & Divya, 2010).

Science education also experienced that paradigm shift. Science as subjects content in curriculum 2013 is an educational program that is oriented in the development of thinking skills, learning ability, curiosity, and the development of caring and responsible attitude towards the social and natural environment. The curriculum 2013 also require students were able to take advantage of information and communication or information literacy, media and Information and Communication Technology (ICT), such as Internet and media ICT (Kemdikbud, 2012). Excellence and finesse computer literacy has increased significantly with the development of multimedia systems and telecommunications capabilities. It provides a logical consequence to the performance of teachers. Computer and other electronic technologies are changing the work of science teachers as much as they are changing the work of scientist (Remziye et al, 2011).

The results of interviews with some of the science teachers of junior high school when visits PPL PPG and PPL S1 obtained information that some schools still have not been able to optimize the school laboratories for laboratory space used setting the schedule of practice for many classes, teachers have difficulties to prepare tools and materials for scientific activities, and to confirm the results obtained by the students based on the results of the laboratory experiments. Based on observations, in the junior high schools computer laboratory is equipped with an LCD and the screen, but it's only used when the students presented the results of the experiment. Teachers often give explanation and clarification about students activities, the directive or the results of students activities verbally. Junior high school in Yogyakarta also have their own computer lab facilities, but its still useless in order to support science teaching and learning activities. Surely, it causes the lack of optimal science learning outcomes.

Meanwhile, learning through experiments in the laboratory is believed as an important

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factor in science education because through laboratory activities the students can understand natural phenomena and develop their scientific reasoning. Some teachers argue that: (1) the real laboratory activities based on hands-on cannot make visualization all science concepts or phenomenon; (2) it also need more time, including the preparation of tools and materials, it must provide right and good instructions in every experimental activity. With the development of information and communication technology, the virtual laboratory as an alternative way to resolve the issue.

Science learning should provide students opportunity to participate in learning process actively. Teachers should be able to develop active learning process so that the students' participation in learning can be increased. Because the vigorous activity of students is the starting point of a learning process, Inquiry learning can be learning approach which is recomended. Inquiry learning can help students to learn and acquire knowledge and develop their own concepts. Through inquiry learning approach, students learn how to organize and conduct research independently so that the concept gained memorable.

In addition, the inquiry approach can develop students' scientific skills, such as process skills, thinking skills (critical and creative), and also the attitude (scientific attitude). The result of Prasojo's (2016) research showed that inquiry learning can develop students' thinking skill, especially critical thinking, because inquiry learning give many chance for the students to explore their thinking skill to solve the problem. Students must use their thinking skill to grouping eksperiment's data, interpreting eksperiment's data, lookking for the connection between facts, make conclusion and explanation about it. Therefore, it is important to use inquiry approach in science learning. Inquiry learning can give many chances to the teacher for exploring the students' ideas, identifying misconception, and directing the students with phenomenon or logic (Ochanji, 2008). Inquiry-based on science education is considered to be an important current trend in science education reform (Alake-Tuenter et al., 2012)

Therefore, it is important to develop a virtual laboratory which is contained with the inquiry approach as a blended learning approach to develop students' thinking skills, because of thinking skills is one purpose of science teaching. The purpose of science learning in a new era emphasis on "Science as a ways of thinking and investigating, as well as a body of knowledge. Virtual laboratory is the one of thing, which is commonly used to assist students in engaging in laboratory activities, followed by remote laboratories, databases, and other miscellaneous technologies (Wang et a., 2014). Virtual laboratory is expected to stimulate students for thinking about the real laboratory activities hands on a computer screen with a depiction of visual and instrument functions and working procedures by using modern multimedia technology. The purpose of this study are to produce inquiry-based science virtual laboratory, and to know how the feasibility of virtual-based inquiry of laboratory science that developed has the potential to improve student's thinking skills by experts and practitioners and to know the influence of the inquiry-based virtual laboratory science in junior high school students in order to develop student's thinking skills.

METHOD

This research is in research and development category. It refers to the model of 4-D and Borg and Gall. The procedure of development consists of four main phases, namely define, design, develop, and disseminate phase; and an additional phase, namely preliminary testing fields, main product revision, playing field testing, and operational product revision taken from Borg and Gall procedure. This research was conducted in June s.d November 2016, in SMP N 1 Jetis Bantul. The subjects were two expert lecturers (subject matter experts and media at the same time) and three teachers and 33 students of class VII F. The type of data in this study includes quantitative and qualitative data as in Table 1.

Table 1.Type of data and its collection technique

Data	Type of data	Collection technique
Data validation of science virtual laboratory	Quantitative and qualitative	Questionarre
Data student' thinking skill test	Quantitatif	Test
Data observation thinking skill	Quantitatif	Observation

The instrument of this research were (1) validation questionnaire sheet of virtual laboratory. It used to obtain data on product assessment from experts and science teachers of

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SMP to the virtual laboratory, with the aspect of assessment include aspects of learning, material substance, software engineering, and visual communication; (2) observation sheet thinking skills; and (3) students' thinking skill test. The data of validation results, students' response, and observation were analyzed descriptively. Based on the data of validation results and observation, the average score of each component aspects of thinking skills was calculated. Then the score is converted using the criteria in Table 2.

Table 2. Category rating criteria

Score range	Grade	Category
X > 1,80 sbi	A	Excellent
0,60 sbi < X ≤ 1,80 sbi	B	Very Good
0,60 sbi < X ≤ 0,60 sbi	C	Good
1,80 sbi < X ≤ 0,60 sbi	D	Fair
X ≤ 1,80 sbi	E	Poor

Data of the implementation of inquiry which is obseved were analyzed descriptively by percentage. The data of students' thinking skill test was analyzed using paired t test to determine the effectiveness of the inquiry-science virtual laboratory for improving students' thinking skills.

RESULT AND DISCUSSION

The results of observation science teaching in junior high school showed that: (1) the computers in the computer laboratory or LCD in the science laboratory on the science lesson does not use optimal; (2) science learning that takes place is still less develop thinking skills; (3) learning media which is used is still not optimized to develop thinking skills; (4) the type of students work sheet (LKS) is still like a cook book (recipes); (5) the majority of junior high school's science teacher still give the confirmation of experiment result verbally. Based on the interview, it obtained information that the teacher is still not use the computer laboratory for science teaching optimally and had not conducting some science experiments because og some factor, namely the limitations of time, procurement of the equipment and materials, and the risk of danger tools or materials.

Based on the analysis of the learning actiivities and curriculum, it is important to make integration between science learning and ICT with a science virtual laboratory in theme "Photosynthesis". Presentation of simulation experiment activities constituted by several considerations, among others: real experimental activities cannot facilitate student to learn about the difficulty of the concepts, limitation of time and tools as well as the difficulties confirmation and visualization of processes that occur in experimental activities. Those can be solved by ICT that is supported as a virtual laboratory. A virtual laboratory has many significant advantages. The results of the Herga et.al.'s (2016) didactic experiment showed that, in terms of knowledge acquisition, using a virtual laboratory is better than science classes without visualization elements.

Virtual laboratory packed with implementing inquiry approach for junior high school students. The guided inquiry approach is chosen in this learning through virtual laboratory because the students are not familiar with inquiry activities. It shows by a simulation experiment guided inquiry activities in the virtual laboratory. The inquiry approach steps are: (1) originating problem; (2) formulating hypotheses; (3) testing the hypotheses; (4) making conclusion; (5) applying conclusion and making generalization (Gulo, 2008).

The inquiry based science virtual media laboratory uses Adobe Flash. Simulation activities presented by animation, along with videos and pictures as well as text. This is to support the students' understanding. In addition, it also equipped with back sound to make it more enjoyable. As for the components contained in the virtual laboratory science are described as follows.

1. Home menu, contains with a virtual laboratory initial view, displays a welcome and introduction that the media is a virtual laboratory on specific subjects. In this menu buttons at the same time available to get to the other menus in the virtual media laboratory.
2. Help instructions menu, contains directives use of virtual laboratory and also the meaning of the symbol of the buttons in the virtual media laboratory.
3. Competence menu contains the basic competencies and learning objectives, which shows the orientation thinking in particular analytical thinking skills.

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Figure 1. Home page menu

4. Material menu contains information that equip students in formulating hypotheses.
5. Practice menu contains simulations of experimental activities and discussion questions at the same time. The menu is served by applying the inquiry approach, which is includes: orientation the problems, formulate the problems, formulate the hypotheses, hypotheses testing, analyze the results and draw conclusions. In this menu, page facilitated discussion questions for the link to the search engine so that students can search for references via the internet.
6. Glossary menu contains a list of scientific terms in a virtual media laboratory science.
7. Bibliography menu contains references used in the preparation of material and experimental activities.

Profile menu contains a brief description of the author and the supporters.

The quality of the inquiry-based science virtual laboratory

The inquiry-based science virtual laboratory rated by two professors and three science teachers based on the indicators included in the instruments used.

Table 3. Results of science virtual laboratory quality assessment

Aspects feasibility	**Expert/Professor(N=2)**		**Teacher (N=3)**	
	Score	**Category**	**Score**	**Category**
Aspect of instruction	3,82	Excellent	3,78	Excellent
Aspects of material substance	3,75	Excellent	4,00	Excellent
Aspects of software engineering	3,72	Excellent	3,89	Excellent
Aspects of visual communication	4,00	Excellent	4,00	Excellent
Average	3,82	Excellent	3,92	Excellent

Table 3 shows that the product rated excellent by experts (professors) and teachers. Experts (professors) and teachers provide comments and suggestions for product improvement. As for suggestions and criticism given by lecturers and teachers as Table 4.

In general, suggestions and criticisms are taken as virtual media repair materials laboratory. One of validator suggestion which is give the additional activity in the menu of practice is not followed because of the high level of difficulty in the manufacture of simulation experiments.

Table 4. The qualitative results of science virtual laboratory assessment

Aspects	**Suggestions and Criticism**
Aspect of instruction	The problem need to be clarified
	Discussion questions need to be systematized
	Practicum activity need to be added
	Exploration of material need to be facilitate by material menu
Aspect of material substance	Scientific name must appropriate with binomial nomenclature
	Questions need to be written clearly so that the concept can be taught essential unexplored
Aspect of software engineering	Operation simulation when objects move need to be give attention for the time of sliding or moving animation
	Information about tool names necessary appear animated when clicked on the relevant tool.
Aspect visual communication	Add information about the introduction of the virtual media laboratory
	Image measuring cups need to be given a clear scale
	Instruction must be with appropriate and clear text
	The color of objects eg wire needs more contrast so obvious

The Effectiveness of the inquiry-based science virtual laboratory to improve thinking skill

Experiments carried out to determine the increase thinking skills by using a inquiry based

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science virtual laboratory. Measurement of thinking skill test done before and after learning by using tests (pretest and post test) and supported with data of thinking skills observation. Students' test results is tested prerequisite (test for normality and homogeneity test). The result of normality are the value of significance (p-value) pretest of $0.177 > 0.05$. It means that all the data are normally distributed. Meanwhile, the homogeneity of the test results show the value of significance (p-value) amounted to $0.841 > 0.05$, which means the data is homogeneous. Based on this prerequisite test can test the hypothesis by paired t test. The results of the t test as Table 6.

Table 6. Results of the t test of thinking skill test scores

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Dev	SEM	Lower	Upper			
Pair 1	pre_test - Post_test	-41.03556	16.17471	2.815	-46.77086	-35.30025	-14.574	32	.000

Table 6 shows that there are significant differences between the thinking skills of students before and after using the inquiry based science virtual laboratory. There is an argument that the laboratory is as a traditional environment to conduct inquiry-based learning. Several studies gathered the evidence that the virtual laboratory is also suitable to fulfill the purpose of scientific investigation. In particular, they are considered equally conducive to active manipulation for experiments which is seen as an important aspect of inquiry learning. In this digital era, it was developed inquiry application online (digital) with a variation in the form of fully online or blended learning (through a combination of synchronous tools). Inquiry approach can help the student to learn as same as the researcher's work to understand, explain, and apply the knowledge (Collete & Chiapetta, 1994). It is supported by the research result show that virtual lab-based learning can improve student mastery of concepts on the topic of dynamic electricity (Flowers, 2011).

In a "virtual laboratory" computers are used, for example, to simulate or animate specific scientific phenomena; pupils normally engage in hands-on activities which are directed towards increasing their understanding and insight of the principles involved. Computer utilities may also be used to simulate complicated, expensive and/or inaccessible devices (for example, a nuclear reactor) or to replace environmentally hazardous laboratory experiments (Rezba, Sprague, & McDonnough, 2006).

Inquiry approach can facilitate the student for thinking with high order thinking to develop their understanding about principles and concepts (Friedel et al., 2008). Thinking skills is the set of basic and advanced skills and sub skills that govern a person's mental processes. These skills consist of knowledge, dispositions, and cognitive and metacognitive operations (Cotton, 1991). The test results were supported by the observation of thinking skills as in Figure 2.

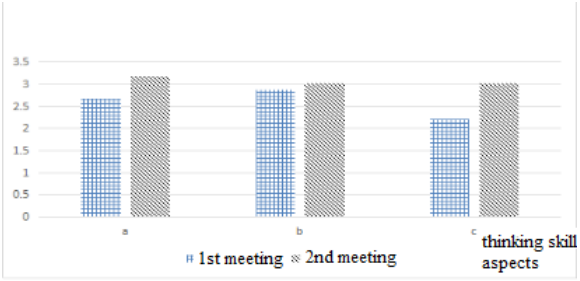

Figure 2. The observation of thinking skill aspects (a=differentiang, b =organizing, c=attributing)

Figure 2 shows that the students' thinking skills has develop from one meeting to the second meeting for each indicator of thinking skills which is observed through science learning by using the inquiry-based science virtual laboratory. These results reinforce the results of the paired t test showed a significant difference. These results are consistent with the theory. These results because of the presence of an important laboratory for virtual media can stimulate students to think about the real laboratory activities (hands on), a computer screen with a depiction of visual and instrument functions and working procedures by using modern multimedia technology. In addition, the virtual laboratory is one form of media assisted learning computer, which allows learning can earn achievements in the form of "complex skills" needed in this global era and can simultaneously engage students actively in

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learning, including in terms of thinking skills. This is reinforced by the results of Brinson's (2015) research that the results of student learning using a virtual laboratory equal or higher than traditional laboratory in all categories of learning outcomes (knowledge, understanding, inquiry skills, practical skills, analytical skills, and scientific communication).

Virtual laboratory help students to confirm and to explain the difference between the experimental results obtained (e.g, error experiments) and theory. Students also have many opportunities to access sources of information and resources and a greater amount of time to complete a special laboratory activities, thus allowing repetition and modification, thereby encouraging deeper learning. In inquiry approach, using media also played a part in improving the thinking skills. This is because the inquiry approach is an approach that can learn students to proceed actively in doing (hands-on) and thinking (minds-on). Teacher must believe that teaching with inquiry approach can stimulate learning behavior, and not just only a transfer of knowledge because the world changing very complex and more condition cannot be solved (Herga, Cagran, & Dinevski, 2016). Ergul's research results. indicates the application of science inquiry learning has a positive effect on cognitive outcomes, process capability, and attitudes toward science (Salam, Setiawan, & Hamidah, 2010). The implementation of virtual laboratory in science learning can support understanding of learning material, teaching critical thinking and improving problem solving (Chiapetta & Koballa, 2010).

CONCLUSION

Based on the results and the discussion above, it can be concluded that product inquiry based science virtual laboratory is assessed with excellent quality by experts and teachers. The inquiry based science virtual laboratory can develop students' thinking skills. It is indicated by the results of paired t test with significance value of 0.000. There is a significant difference between the mean of students' thinking skills score before and after learning using the inquiry based science virtual laboratory in science learning.

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