The Implementation of Levels of Inquiry With Writing-To-Learn Assignment To Improve Vocational School Student's Science Literacy

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Abstract. The aim of this study was to investigate the effectiveness of writing-to-learn assignment in a levels of inquiry learning to improve vocational school student's science literacy competence and knowledge on the subject of temperature and heat . This study used quasi experiment research methods. The data were obtained using 16 item of science literacy instrument with essay format. The result shows that there was a significant difference on the improvement of science literacy ability between the experimental class and control class. A significant difference occurred in the evaluating and designing experiments competency, interpretating data and science evidence competency, and procedural knowledge . Therefore it can be concluded that the implementation of levels of inquiry with writing-to-learn assignment can improve vocational student's science literacy competence and knowledge.

1. Introduction

The development of science and technology has been helping human to improve their quality of life, however this development is also carry negatives impact such as energy dissipation, destroying nature activities, etc. Hobson [1] stated "If an industrialized nation is democratic, its citizens must ultimately make the crucial choices about the uses of science and technology". This is imply that its neccesary for citizens to have a literacy of science and technology. Therefore, it will be important for us to consider the science literacy as one of the concerns and objectives in conducting science education in the basic education level or in higher education.

Based on the results of PISA (Programme for International Student assessment) in 2000, 2003, 2006 and 2009, the science literacy skill of Indonesian students are respectively at positions 38, 38, 50, and 60, significanly below the international average [2]. Based on the results of preliminary studies in one of the secondary schools in Ciamis, using the science literacy test instruments that are designed based on science literacy assessment PISA 2015, students science literacy skill is still quite low in both the competence and knowledge. This is indicate that the learning process doesnt facilitated students to achieve science literacy as the learning process tend to present science merely as a body of knowledge that students need to memorize. Therefore, its important to emphasize learning process that present science not merely as a body of knowledge, but also as a way to knowing about how the nature work. To achieve that goal, the learnig process has to give a sight to students how scientist do the science work, one way is to using inquiry learning in the science classroom, as Fang and Wei [3] stated that the literature in science education has been emphasized on inquiry activities in the development of science literacy.

Wenning [4]has proposed Levels of Inquiry as a sequences of lessons arranged hierarchically starting from the level of discovery learning, interactive demonstration, inquiry lesson, inquiry laboratory, realworld application, and hypothetical inquiry. Rohmi [5]have applied levels of inquiry on the theme of environmental pollution to improve science literacy. The results showed that there is an increased in students competence and knowledge of the science literacy after learning. However, this increase science literacy domain is not distributed evenly in every aspect, as smallest increase was in the epistemic knowledge and design and evaluate a scientific investigation competency.

Yore [6]stated that doing more hands on activity is not enough to improve meaningful learning, students need opportunities to strengthen his scientific experience and to contrast his understanding with the interpretation of the scientific establishment. This statement is similar to Glynn and Muth's [7]that state what is necessary to achieve science literacy is the emphasis on "minds on" in the study of science. One strategy that can be applied is to involve writing activities into science lessons. Peterson & Rochwerger [8]states that writing is a process that helps students to think more deeply about the ideas and information they encounter through reading, listening, watching and their exp9erience about the world around them. Baker et al. [9]states that the importance of writing skills of students to be attentive to all teachers, especially when using inquiry-based approach in science classes.

Keys et al. [10]stated that the nature of writing task for laboratory activity is depends on the nature of the activity of such labs. From the epistemological standpoint, traditional lab reports is appropriate for traditional laboratory activities. As for the Inquiry laboratory activities are still need to consider how is the appropriate writing form. One of suitable form is Science Writing Heuristic (SWH) which it is a tool to promote thinking, negotiate meaning, and writing about laboratory activities[11]. Science Writing Heuristic is a writing framework that designed to provide guidance for students to conduct laboratory investigations. SWH can be used as an alternative format of the laboratory reports but also can be used as a teaching model with the activity lab as a process of knowledge building and include arguments into inquiry based teaching [12].

Based on the preliminary study and the description above, researchers interested in studying the use of science writing heuristic in levels of inquiry strategy to improve students science literacy. In this study, science literacy is referring to the framework of assessment of science literacy PISA 2015 [13] which includes the competence and scientific knowledge. The problems in this research are:

1. How does the effect of use of levels of Inquiry with writing-to-Learn assignment to the improvement of students science literacy knowledge?
2. How does the effect of use of levels of Inquiry with writing-to-Learn assignment to the improvement of students science literacy competence?

2. Experimental Method

Considering the research needs and time constraints, the sample selection was not done randomly, but based group that has been formed previously, methods in such research is quasi experimental research methods [14]. The sample was 59 students of class XI at a vocational school in Kabupaten Bandung, West Java, distributed to the control class and experimental class. Control class was used the levels of inquiry learning on the subject of temperature and heat, while the experimental class was used the levels of inquiry learning with the writing-to-learn assignment. Both of class used the levels of inquiry proposed by Wenning [4]from discovery learning, interactive demonstration, inquiry lesson to inquiry lab. In the experimental group, after inquiry lab, students are asked to write down a personal meaning of laboratory activities that have been done following the students template proposed by keys [10]as presented at figure 1.

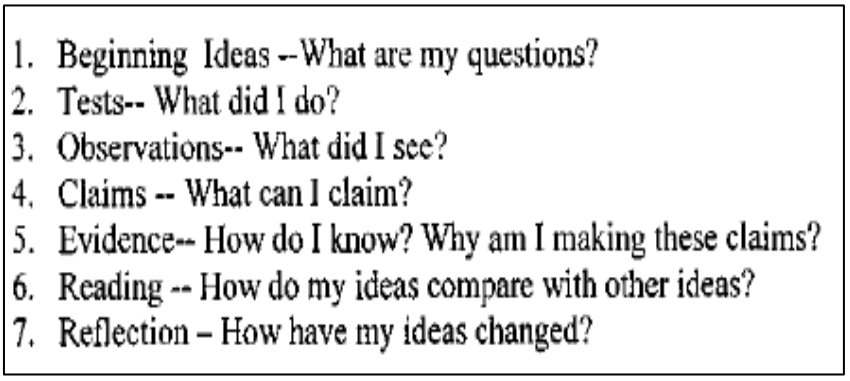

Figure 1. Student's Template

Then the students were asked to conduct discussions with his peers about the writings that have been made, then a representative student of the group presented the results of his writings in the classroom to get feedback from the teacher. After the lesson, the students were given the assignment to revise his writings at home by reference to the textbooks or online sources. The learning sequeces for both of class are presented in table 1.

Table 1: Learning sequences on control group and experimental group

LOI cycle	Day	Group	
		Control	Experimental
1	1	*Discovery Learning* *Interactive Demonstration* *Inquiry Lesson*	*Discovery Learning* *Interactive Demonstration* *Inquiry Lesson*
	2	*Inquiry Lab* -	*Inquiry Lab* *Writing-to-learn*
2	3	*Discovery Learning* *Interactive Demonstration* *Inquiry Lesson*	*Discovery Learning* *Interactive Demonstration* *Inquiry Lesson*
	4	*Inquiry Lab* -	*Inquiry Lab* *Writing-to-learn*

The test instrument has been matched to the PISA science literacy assessment, consists of 16 essay questions.Normalized gain value is used to determine the improvement of science literacy and then interpreted by using criteria proposed by Hake [15]. Based on normality test results, the n gain data are not normally distributed. thus, the hypothesis is tested by using "MannWhitney U Test". To determine the effect of the treatment to learning outcomes, we calculated effect size with cohen's formula.

3. Result and Discussion

3.1. The Improvement of Students' Science Literacy

Table 2 shows that there is an improvement of students' science literacy in the medium category both in experiment and control class. Both categorized as average improvement.

Table 2. Gain normalized of student's Science Literacy

Class	Pre-test	Post Test	N-Gain
Experiment	14,29	55,36	(0,48) Average
Control	17,64	43,25	(0,31) Average

To determine whether the differences in improvement of the control class and experimental class significant or not, then we used the statistical test analysis to test the hypothesis using MannWhitney test. Results of the hypothesis testing presented in the table 3 show that the differences catagorized as signifficant;

Table 3. Results of MannWhitney science literacy

Mean Rank of the control class (N=31)	Mean Rank of the experiment class (N=28)	Sig.	Decision
21,85	39,02	0,000	Significant

Based on the results of statistical hypothesis test nonparametric MannWhitney Asymp values obtained. Sig. (2tailed) or a pvalue of 0.000 where the value is smaller than the specified significance value (p. 0,000 <α. 0,05) with a 95% confidence level. Thus the null hypothesis was rejected, and the alternative hypothesis is accepted that that increase science literacy of students in the experimental group was significantly greater than the increase science literacy of students in the control group.

3.2. The improvement in the respective competence and knowledge of science literacy

Table 4 showed that there are average improvement on every aspect of science literacy knowledge both in experiment class and control class except on procedural knowledge of control group which its improvement categorized as low.

Table 4. Improved knowledge of each component of students' science literacy

No	Knowledge Type		Average Score		
			Initial test	Final test	N gain
1	Content	Experiment	27,97	56,32	0,39 (average)
		Control	24,19	50,53	0,35(average)
2	Procedural	Experiment	10,93	51,5	0,46(average)
		Control	18,14	39,11	0,26 (low)
3	Epistemic	Experiment	11,42	54,82	0,49(average)
		Control	12,9	45,48	0,37(average)

To determine whether the differences in improvement of the control class and experimental class on every aspect of science literacy knowledge significant or not, then we used the statistical test analysis to test the hypothesis using MannWhitney test. Results of the hypothesis testing presented in the following table;

Table 5. MannWhitney Test Results at each domain knowledge

Knowledge	Mean Rank of the control class (N=31)	Mean Rank of the experiment class (N=28)	Sig.	Decision
Content	27.31	33.09	0.186	Not significant
Procedural	20.74	40.25	0.000	Significant
Epistemic	25.92	34.52	0.053	Not significant

Table 5 show that the only significanly different improvement of the science literacy knowledge beetween control class and experiment class is on procedural knowledge. Beside the knowledge component, an analysis toward the components of science literacy competence was also conducted. Description of improvement of each competency is described in Table 6.

Table 6. The improvement of each component of competency of students' science literacy

No	Science Literacy Competency		Average Score (%)		
			Initial test	Final test	N-gain
1.	Explaining phenomena scientifically	Experiment	27,97	56,32	0,39
		Control	24,19	50,53	0,35
2.	Evaluating and designing experiments	Experiment	11,16	46,76	0,40
		Control	16,93	37,09	0,24
3.	Interpreting data and scientific evidence	Experiment	11,07	62,41	0,58
		Control	14,83	48,7	0,40

To determine whether the differences in improvement of the control class and experimental class on every aspect of science literacy competence significant or not, then we used the statistical test analysis to test the hypothesis using MannWhitney test. Results of the hypothesis testing presented in the table 7;

Table 7. MannWhitney Test Results at each domain of competency

Competency	Mean Rank of the control class (N=31)	Mean Rank of the experiment class (N=28)	Sig.	Decision
Explaining phenomena scientifically	27.31	33.09	0.186	Not significant
Evaluating and designing experiments	21.97	38.89	0.000	Significant
Interpreting data and scientific evidence	23.66	37.02	0.003	Significant

Table 7 show that there are significantly different improvement of the science literacy competency beetween control class and experiment class on evaluating and designing experiments competency and Interpreting data and scientific evidence competency. Results of the effect size calculation, shows that the treatment have a large effect to students science literacy. The calculation result presented in table 8;

Table 8. Effect size calculation result

knowledge	**d value**	**Category**
Procedural	10.76	Large effect
competence	**d value**	**Category**
Evaluating and designing experiments	4.23	Large effect
Interpreting data and scientific evidence	1.68	Large effect

3.3. Disscusion

Results of this study shows that the implementation of levels of inquiry strategies improve the science literacy of students. These findings are in line with previous studies that the learning lab by using inquiry strategy can improve science literacy of students [16]; [3]. With using levels of inquiry students are given the opportunity to be actively involved in the activities of scientific investigations so that they can develop the skills of their intellectual processes [17].

In the domain of competency, increase in scientific competence of students in the experimental group was significantly greater than the control group was in the evaluate and design a scientific investigation competency to and interpret the data and scientific facts competency, the effect of the treatment to both of these competencies are catagorized as large effect. Evaluating and designing scientific investigations competency are covering describe and assess the scientific investigation and propose ways to ask the question scientifically [13]On the writing-to-learn activities students are asked to write back what he did during the experiment, students were asked to create a proposition that describes what he did to answer the research question. Then students conduct a disscussion with his group, and then communicate the results of group discussion in front of the class. Then the results of the discussion group discussed jointly guided by the teacher to reflect on lab activities that have been done, such as the selection of tools and materials, experimental procedures, and the importance of controlling the experiment. Students are facilitated to interpret each of the steps and procedures of his experiment, in line with the statement of keys et al [10]that the activity in students template in writing-to-learn students reviewing procedures performed (both the procedure prepared by the teacher and the student) and observation for linking it directly with the research questions. Students are also encouraged to make an analysis of the experiments that have been done by comparing the experimental results that have been obtained to a written or online source in a hypothetical inference proposition, it can help students to improve their ability to design and evaluate experiments. Interpret the data and scientific facts competency covering analyze and evaluate data, questioned and argued in various representations and draw appropriate scientific conclusions [13]. On the writing-to-learn activities students are asked to make a claim from the experiment that they did, in addition students are also required to provide proof that lead students to make the claim, and then students compare the his claims to his peer, and also contrasting with other valid sources. In the final phase, students are asked to create a narrative about how his ideas change. Students are facilitated to make and reexamine the ideas and scientific claims are made, and the change of claims that have been made. This is similar to the claim of the Balgopal & Wallace [18]that the activity of writing to learn allows students to reexamine its ideas and modify the supporting facts for them to make a claim. This of course help students to be able to improve their competence in interpreting the data and scientific evidence.

The experimental group have significantly greater increase on procedural knowledge than the control group was. The effect of the treatment to this knowledge is catagorized as large effect. Procedural knowledge can be defined as knowledge of standard procedures used scientists to obtain reliable and valid data [13] On the writing-to-learn activities students are asked to to write a personal meaning and groups of procedures and the experimental results indicted. By doing that the students rewrite the ideas, designs, procedures, research results and conclusions that can be drawn from the investigation activities. This form a knowledge for students about the appropriate procedures and less appropriate procedures in order to answer the research question, as revealed by the Hand [19] that the new knowledge will be formed for the task of writing requires existing knowledge to be delivered in a way that has not been never been done before, and this led to a conceptual framework setting different topics.

4. Conclusion

Implementation of the levels of Inquiry strategy with the writing-to-Learn assignment can significantly improve the science literacy competence of students evaluating and designing scientific investigations, the competence to interpret the data and scientific facts, and procedural knowledge compared with levels of Inquiry learning only strategy. This research is empirical evidence that supports earlier studies, that the application of the levels of inquiry with the assignment of writing-to-learn can improve science literacy of students. A challenge for teachers is to integrate the activities of inquiry with the task of writing, that is necessary to train the students to be able to bring expected propositions. Teachers are expected to give an example of writing that shows these criteria on this training.

5. References

[1] Hobson A 2008 *The Surprising Effectiveness of College Science literacy Courses*. The Physics Teacher **46**
[2] Balitbang Kementrian Pendidikan dan Kebudayaan. 2011*Survei Internasional PISA*. [online].
[3] Fang Zand Wei Y 2010 Improving Middle School Students' Science LiteracyThrough Reading Infusion. *The Journal of Educational Research*
[4] Wenning C J 2005 *Journal Physics Teacher Education* Online **2**(3)
[5] Rohmi P 2015 *Penerapan Levels Of Inquiry untuk Meningkatkan Domain Kompetensi dan Pengetahuan Literasi Sains Siswa SMP pada Tema Pencemaran Lingkungan*. Tesis Sekolah Pascasarjana UPI. Tidak diterbitkan.
[6] Yore L D 2000 *Journal of Deaf Studies and Deaf Education* **5 (**1) Winter
[7] Glynn S M and Muth K D 1994 *Journal Of Research In Science Teaching* **31**(9) 1057-073
[8] Peterson S S and Rochwerger 200 6*Cross-Curricular Literacy: Writing for Learning in a Science Program*. Voices from the Middle **14 (**2)
[9] Baker, W et al. 2008 *A Journal of Educational Strategies, Issues and Ideas*
[10] Keys et al. 1999 *Journal Of Research In Science Teaching*
[11] Hand B, Wallace C W and Yang E 2004 *International Journal of Science Education* **26**(2) 131-49
[12] Xu H and Talanquer V 2012 *Journal of Chemical Education*
[13] OECD 2013 *PISA 2015 Draft Science Framework*
[14] Creswell J W 2009 *Research Design; Qualitative, Quantitative and Mixed Method Approach. Third Edition* (California: SAGE Publication)
[15] Hake R R 1999 *Analyzing Charge Gain Score*. Avalaible at http://www.physics .indiana.edu/Analyzing Change Gain.pdf
[16] Gormally et al. 2009 *International Journal for the Scholarship of Teaching and Learning*
[17] Wenning C J 2007 *Physics Teacher Education Online* **4**(2) 3-14
[18] Balgopal M and Wallace A 2013 Writing-to-Learn, Writing-to-Communicate & Science Literacy (*The American Biology Teacher* Vol. 75) (California : University of California Press)
[19] Hand et al. 2006 *International Journal of Science and Mathematics Education* 125Y143