Effectiveness of CPI(Construction,Production,and Implementation)Teaching Model to Improve Science Literation for Pre-service Physics Teacher)

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Abstract. The CPI (Construction, Production, and Implementation) teaching model is a physics learning design to facilitate positive attitude of pre-service physics teacher in constructing science literacy and producing the science literacy learning. The purpose of this study is to analyze the effectiveness of the CPI teaching model to increase the science literacy of pre-service physics teacher in the academic year of 2016/2017. This study used pre-experiment with one group pre-test and post-test design toward 152 pre-service physics teacher who were divided into 5 groups at State University of Surabaya and University of Lambung Mangkurat Banjarmasin (Indonesia). The data collection that used Science Literacy Test Sheet (SLTS) emphasized on the indicator of using physical knowledge to explain phenomena scientifically, evaluating and designing scientific inquiry, interpreting data and providing scientific evidence. The data analysis techniques were performed with Paired t-test, N-gain, and ANOVA. The results showed that there was a significant increase of science literacy from pre-service physics teacher at $\alpha = 5\%$, n-gain value of each group was medium, and there was no different increase (consistent) for the five groups. Thus, the CPI teaching model is effective to increase the science literacy pre-service physics teacher.

Key words: CPI teaching model, physics learning, pre-service physics teacher, science literacy

Introduction

"Literate science or early retirement" a thought for the importance of increasing the science literacy competence of physics teachers in Indonesia today. In Indonesia which has a variety of natural resources and human resources, the population of 240 million is believed to be a supporting element for this nation to be great in the future (Rokhman, Syaifudin, Yuliati, 2013; Suyidno, Nur, Yuanita, Prahani, & Jatmiko, 2018). Considering that science has become a tool in the realization of a society's desire to dominate another society (Eren, 2016; Jimenez, Fernandez, & Franco, 2016; Kildan, Pektas, & Uluman, 2015); the cultural of science literacy in the world of education and in the life of Indonesian society is necessary to accelerate the progress and glory of the nation. Therefore, pre-service physics teacher as the spearhead of education and change agent of the nation in the future; need to master not only the content of science literacy, but also pedagogy (planning and teaching) of science literacy well (Eggen & Kauchak, 2013; Setiadi, 2013; Udompong, Traiwicitkhun, & Wongwanich, 2014). Through the government's policy Number 44 of 2015 on National Standards of Higher Education, the Government of Indonesia set the competency standards of physics education graduates that they should be able to literate science, namely; mastering the field of physics in depth, applying the field of physics and technology used in solving problems, making the right decision based on data analysis and information, and choosing various alternative solutions independently. Pre-service physics teacher are prepared to face the impact of science and technology development (Turiman, Omar, Daud, & Osman, 2012), supporting sustainable development (Udompong & Wongmanich, 2014), and able to teach science literacy well (Eggen & Kauchak, 2013; Villaneuva, 2010).

The development of science literacy includes the main goals of physics education in various parts of the world (Ennis, 2015; Blascova, 2014; NRC, 2011; Odegard, Haug, Mork, & Sorvik, 2015; Wang & Zhao, 2016); including in Indonesia. Science literacy is the ability to use science knowledge to explain phenomena scientifically, evaluate and design scientific inquiry, interpret data and provide scientific evidence (OECD, 2013, Ozdem, Cavas, Cavas, Cakıroglu, & Ertepınar, 2013; Ratcliffe, 2012; Thomson, Hilman , & Bortoli, 2013). Science literacy facilitates the process of scientific inquiry that leads to scientific knowledge, practical decision-making and solving real-life problems (Abersek, Dolenc, Flogie, & Koritnik, 2015; Bingle & Gaskell, 1994; Demirel & Caimaz, 2015; Dragos & Mih, 2015; Gormally, Brickman, & Lutz, 2012; Lamanauskas, 2012; Mumba, Chabalengula, & Hunter, 2006; Norris & Phillips, 2003). Science literacy helps to understand the impact of science and technology, keep up with the latest news or science reports, make decisions and actively participate in public discourse on science issues (Impey, 2013; Yaslin, Acisli, & Turgut, 2011). Development of science literacy in physics learning is emphasized on the indicators of: (1) explaining the phenomenon scientifically. Students can use their knowledge about physics to explain scientific phenomena, technological products, and real-life problem solving, and decision-making on science issues; (2) evaluating and designing scientific inquiry. Students distinguish scientific and unscientific questions, identify scientific questions, design scientific inquiry (formulate hypotheses, identify variables, create operational definitions of variables, design observational data tables, design investigation procedures), and (3) interpreting data and providing scientific evidence. Students transform data from one representation to another, and analyze and draw conclusions appropriately (Gormally, Brickman, & Lutz, 2012; OECD, 2013; Ratcliffe, 2012; Thomson, Hilman, & Bortoli, 2013). Based on the above explanation, the development of science literacy for pre-service physics teacher is emphasized on indicators of using physics knowledge to explain the phenomenon scientifically, evaluate and design scientific inquiry, interpret the data and provide scientific evidence.

Pre-service physics teacher play an important role in cultivating science literacy in schools and in community life later (Yaslin, Acisli, & Turgut, 2011). Therefore, the students must master the content of science literacy along with its elements and be able to teach science literacy in class well (Eggen & Kauchak, 2013; Udompong, Traiwicitkhun, & Wongwanich, 2014). In fact, the process of physics learning is still dominated by lectures and the limitations of the opportunity to expose the material of physics from real life make students less understand the essence of science literacy (Menristekdikti, 2014). The preliminary study of Sunarti (2015) found that the mastery of the science literacy of pre-service physics teacher in Unesa is still low, because there were only 52.3% of students were able to use their physical knowledge to explain the phenomenon scientifically; evaluate and design scientific inquiry (9.3%); interpret data and provide scientific evidence (23.8%); plan science literacy learning (6.6%). This is reinforced by research results of Suliyanah, Putri, & Rochmawati (2017) and Yusuf, Prabowo, & Prastowo (2017) that student of pre-service physics teacher in Unesa still have difficulty in connecting physics material with technology product and real life problem solving. This problem also happened to the pre-service physics teacher in University of Lambung Mangkurat Banjarmasin (Hartini, Zainudin, & Annur, 2012; Jamal & Suyidno, 2015; Suyidno & Nur, 2015). The above findings indicate that the low science literacy of pre-service physics teacher becomes the main problem of higher education in Indonesia, especially in Unesa and ULM, which must be resolved soon.

Innovative learning models that have been used to tap the science literacy include: (1) Problem Based Learning (PBL) which can improve physics teachers' learning achievement (Celik, Onder, & Silay, 2011); critical thinking in studying physics (Siew & Mapeala, 2016); understanding of the physics phenomenon, scientific inquiry, problem solving, and development of a deep physics understanding (Ali & Shah, 2013). PBL helps physics teachers explain the nature of science, helps students understand the social and cultural impacts of science development, and recommend the importance of contemporary scientific realities and their applications (Moutinho, Torres, Fernandes, & Vasconcelos, 2014) and the depth of instruction in exploration (Nariman & Crispeels, 2015); (2) Integrated Teaching Strategy (ITS) which can improve problem solving skills, science literacy, communication and pedagogical practices in science, and recommend the need for further exploration to advance theoretical perspectives and practical approaches in teaching science (Villaneuva, 2010); and (3) Investigation Based Learning (IBL) which can improve exploration, discussion and reflection skills through the exchange of ideas in generating the idea of scientific investigation, and physics teacher candidates should be equipped with the ability to develop comprehensive scientific literacy and its assessment (Setiadi, 2013). Based on the above recommendations, the weaknesses of PBL, ITS, and IBL can be improved by developing an innovative model of effective physics learning to increase the science literacy of pre-service physics teacher.

The learning model which was developed is the CPI (Construction, Production and Implementation) teaching model as a recommendation for improvement of PBL, ITS, and IBL including: (1) the importance of contemporary science essence and its application (Moutinho, Torres, Fernandes, & Vasconcelos, 2014); (2) the depth of instruction in exploration (Nariman & Crispeels, 2015); (3) further exploration to advance theoretical perspectives and practical approaches in the science teaching (Villaneuva, 2010); and (4) development of science literacy learning along with its assessment (Setiadi, 2013). In other words, pre-service physics teacher are not only equipped with science literacy content, but also the ability to plan and teach science literacy well. This is consistent with Young & Friedmen (2012) and Walker (2014) that physics studies the physical world and the principles governing behaviors that have been studied through experiments and observations of natural phenomena. The study of physics deals with the complexity of the physics field with technology on the one hand and the responsibility to society on the other hand (Bilek, 2016; Demirel & Caimaz, 2015; Jimenez, Fernandez, & Franco, 2016). Pre-service physics teacher can provide a rational explanation of the world in order to be easily understood; support open, objective and fair thinking and dependent empirical evidence; support the need for critical and creative thinking about assumptions, ideas, testings and interpretations (Yaslin, Acisli, & Turgut, 2011; Yilmaz & Cavaz, 2016).

The development of the CPI teaching model by using a transdisciplinary approach (physics, psychology, education, technology) was to produce creative, original, and tested learning model to address the problem of low positive attitudes toward science, science literacy skills, and design science literacy learning for pre-service physics teacher. The development of CPI teaching model is supported by learning theories (advanced organizers, constructivism, observational learning, discovery learning, cognitive process, metacognition skills, distributed cognition learning, whole language learning, self-regulated learning, and scaffolding) and empirical foundation of recent studies. Positive attitudes toward science are emphasized in the motivation of learning science, beliefing in learning science, supporting the scientific inquiry, and responsibility for resources and the environment (OECD, 2013; Thomson, Hilman, & Bortoli, 2013). A positive attitude toward science can encourage physics-aspiring students to try to understand science literacy and confidence in teaching, and contribute to the formation of student attitudes and behaviors later (Aktan, 2016; Cibir & Ozden, 2017; Dragos & Mih, 2015; Ennis, 2015; Senler, 2016). The development of science literacy emphasizes the use of physical knowledge to explain scientific phenomena, to evaluate and design scientific inquiry, to interpret data and to provide scientific evidence (OECD, 2013; Thomson, Hilman, & Bortoli, 2013). Students are directly involved in scientific investigation, decision-making and solving real-life problems (Demirel & Caimaz, 2015; Ennis, 2015; Ozturk, 2016; Rannikmae, 2016). Students are not only equipped with positive attitudes toward science and science literacy content, but also pedagogical knowledge (such as making syllabus, lesson plan, student worksheet, assessment sheet) to teach science literacy (Eggen & Kauchak, 2013; Udompong, Traiwicitkhun, & Wongwanich, 2014) .

The CPI teaching model is designed to facilitate the development of positive attitude of pre-service physics teacher in constructing science literacy and producing science literacy learning plans (Sunarti, Madlazim, & Wasis, 2017a; 2017b). CPI teaching model syntax begins with phase 1: Motivating students to literate science. Phase 1 aims to increase students' motivation and confidence in supporting the success of science literacy construction and science literacy learning production in the next phase. Lecturers motivate students by presenting science issues (source: the latest news or science reports) to inspire them to ask scientific and unscientific questions bravely; convey the learning objectives and the importance of positive attitudes toward science, and help to prepare the necessary logistics in exploration. Phase 2: Guiding the construction of science literacy in groups. This phase aims to cultivate a positive attitude of students in constructing their own science literacy through their personal experience with others and the environment. Students are directly involved in scientific investigation, decision-making and real-life problem solving. The lecturer's activities are designed in the form of cycle I consisting of five steps namely: (1) identification, the lecturer asks students to read science issues in students worksheet, then identify the concepts in science issues and write down some problem formulas that are allowed to be investigated; (2) exploration, facilitating scientific investigations by formulating hypotheses, identifying variables, making operational definitions of variables, designing observational data tables, designing experimental procedures, conducting experiments, and reviewing various reference sources; (3) explanation, consolidating students' confidence in using scientific information found to explain scientific issues; (4) application, confirming students' confidence in explaining other scientific phenomena, technology products, problem solving, and decision-making related to other scientific issues; and (5) reflection, facilitating discussion of group work in front of the class. Phase 3: Producing and implementing science literacy learning. Lecturer's activities are designed in the form of cycle II consisting of three steps, namely: (1) identification, guiding students to identify examples of science literacy lesson plan, then identifying the physical topics to be developed in learning; (2) development, facilitating the development of learning ideas by preparing the science literacy lesson plan referring to students worksheet, providing consultation opportunities and group discussions in order to produce a qualified lesson plan; (3) implementation, guiding the lesson plan/peer teaching simulation in front of the class and discussing the results, then giving the responsibility to revise the lesson plan. Phase 4: Evaluation and reflection. Lecturers involve students in the evaluation of science literacy results and the learning process undertaken. The CPI teaching model has been developed by design to increase the science literacy of pre-service physics teacher and has been declared valid by science literacy learning experts. Furthermore, it will be analyzed to what extent the effectiveness of CPI teaching model in increasing the science literacy of pre-service physics teacher.

Problem of Research

The main problem of this research is to analyze the effectiveness of CPI teaching model to increase the science literacy of pre-service physics teacher. The effectiveness of the CPI teaching model is measured by: (1) the increase of science literacy from pre-service physics teacher significantly at the level of significance, $\alpha = 5\%$; (2) the average level of science literacy improvement for pre-service physics teacher is determined with normalized gain (n-gain) value of at least medium category; and (3) the average level of science literacy improvement for pre-service physics teacher in the five groups are not different significantly.

Research Focus

The purpose of this research is to know the effectiveness of CPI teaching model to increase the science literacy of pre-service physics teacher. The focus of the problem in this study includes: (1) whether there is a significant increase (statistically) in the science literacy of pre-service physics teacher before and after the application of CPI teaching model, (2) how big is the level of science literacy improvement from the pre-service physics teacher before and after the application of CPI teaching model, (3) whether there is a difference in the increase of science literacy from pre-service physics teacher after the learning with CPI teaching model in the five groups.

Methodology of Research

General Background of Research

This research was conducted at State University of Surabaya (Unesa) and University of Lambung Mangkurat (ULM) Banjarmasin from March 2016 until June 2017. The scope of this research was the fourth year students who took internship 1 course in academic year of 2016/2017. This research was emphasized on the analysis of the CPI teaching model effectiveness fulfillment by analyzing the increasing of science literacy from pre-service physics teacher before and after following the physics learning with CPI teaching model. The effectiveness of the CPI teaching model was determined by the statistically significant increase of the science literacy pre-test and post-test of pre-service physics teacher, and the n-gain average was determined by the criteria of: low, medium and high.

Sample of Research

The selection of samples was based on the Slovin formula, i.e. Sample = [population / (1 + e^2 x population)] with error tolerance e = 5% (Sevilla, Ochave, Punsalam, Regala, Uriarte, 1984). The sample in this research were 152 pre-service physics teacher at Unesa and ULM, Indonesia; which was divided into five groups, namely: group-1 (32 students of class A Physics Education, Unesa), group-2 (32 students of class B Physics Education, Unesa), group-3 (24 students of class C Physics Education, Unesa) group-4 (32 students of Class A Physics Education, ULM), and group-5 (32 students of class B Physics Education, ULM) from the population of 188 pre-service physics teacher who took internship course 1. Consideration in choosing student of physics education program Unesa and ULM was due to the initial mastery of the science literacy content and pedagogy from the pre-service physics teacher. The ease of physics laboratory equipment facilities was also a consideration in choosing the research subject.

Instrument and Procedures

This study used pre-experiment with one group pretest-posttest design, that is O1 X O2 (Fraenkel, Wallen, & Hyun, 2012). The learning process began with pre-test (O1) in the five groups. Each student was required to work on the Science Literacy Test Sheet (SLTS). SLTS is adapted from scientific literacy's assessment (Thomson, Hilman, & Bortoli, 2013) and Test of Scientific Literacy Skills (Gormally, Brickman, & Lutz, 2012) emphasized on the indicators of explaining phenomena scientifically, evaluating and designing scientific inquiry, interpreting data and providing scientific evidence. The quality of SLTS is determined by the result of calculation of the validity and reliability presented in Table 1.

Tabel 1. Validity and Reliability of SLTS.

Indicator	Science Literacy Test Sheet Items	Validity		Reliability	
		Score	Criteria	α	Criteria

Use physical knowledge to explain phenomenon scientifically.	Explain the phenomenon scientifically.	1. When given an image of a thousand images mirror, students can explain the type of mirror used along with the process of thousand images occurance (explain the phenomenon scientifically).	3.00	Valid	.79	High
	Analyze problem solving.	2. When given information black smoker on the seabed, students can determine the pressure that occurs in black smoker vents.	3.00	Valid		
	Describes technology products.	3. When given information and technology products of swimming glasses, students can explain why the use of swimming glasses can help to see clearly objects in the water.	3.00	Valid		
	Make a decision.	4. When given the problem of farsightedness, students can choose contact lenses or glasses to deal with farsightedness and its explanations.	3.00	Valid		
Evaluate and design scientific inquiry.	Distinguish scientific and unscientific questions.	1. When given the questions relating to the condition of the store, students can distinguish between scientific and unscientific questions.	3.67	Very Valid		
	Identify scientific questions.	2. When given the scientific issues of "Find Alien, China Build World's Largest Telescope," students can write down some possible scientific investigation questions.	3.67	Very Valid		
	Design exploration.	3. When given the science issues of "Find Alien, China Build World's Largest Telescope," students can plan an experiment correctly.	3.00	Valid		
Interpret data and provide scientific evidence.	Transform data from one representation to another.	1. When given information of a car that appears on the rearview mirror, students can determine the magnification of the car image by making an image and using a mathematical calculation.	3.67	Very Valid		
	Analyze and draw conclusions appropriately.	2. When given the camera experiment data, students can draw conclusions appropriately.	3.00	Valid		

Note: α = *Cronbach's Alpha* Coefficient
(Sunarti, Madlazim, & Wasis, 2017a)

Table 1 shows that SLTS validity includes the use of science knowledge to explain scientific phenomena (items 1, 2, 3, 4); evaluate and design scientific inquiry (items 5, 6, 7); interpret data and provid scientific evidence (item 8, 9) obtain valid/highly valid criteria. Cronbach's Alpha coefficient was .79; so the result of expert judgment on SLTS validity has high reliability criteria (Sunarti, Madlazim, & Wasis, 2017a). Previous research by Sunarti, Madlazim and Wasis (2017b) showed the validity of the CPI teaching model by three science literacy learning experts, that in the range of scores between 1 and 4, the average score for content validity was 3.59 (very valid) and construct validity was 3.43 (very valid); as well as the Cronbach's Alpha coefficient was respectively .73 and .77; so the results of the content validity and construct validity of the CPI teaching model had high reliability criteria. In addition, the result of the validity assessment for the syllabus was 3.59 (very valid); lesson plan was 3.72 (very valid); textbook was 3.32 (very valid); worksheet was 3.30 (very valid); and science literacy lesson plan example was 3.40 (very valid). This indicates that the CPI teaching model met the criteria of content validity (needs and upgrades) and construct validity (consistency between model components); and supported by learning tools (syllabus, lesson plan, textbook, worksheet, science literacy lesson plan example, assessment sheet) in valid criteria.

Lecturers carry out the learning process by using learning tools with CPI teaching model for 9 meetings (X). Lecturer and student activities are presented in Table 2.

Table 2. The activities of lecturers and students for 9 meetings.

	Syntax		Activity in meeting number …								
			1	2	3	4	5	6	7	8	9
1.	Motivate students to literate science.	Presents science issues	x	x	x	x	x	x	x	x	x
		Learning objectives	x	x	x	x	x	x	x	x	x
		The importance of positive attitudes toward science	x	x	x	x	x	x	x	x	x
		Presents logistics	x	x	x	x	x	x	x	x	x
2.	Guide the construction of science literacy in groups.	Identification	x								
		Exploration	x								
		Eksplanation	x								
		Application	x								
		Reflection	x								
3.	Produce and implement science literacy learning.	Identification		x							
		Development		x*	x*			x**	x**		
		Implementation				x	x			x	x
4.	Evaluation and reflection.		x	x	x	x	x	x	x	x	x

Note: * Development of Lesson Plan in groups, ** Development of Lesson Plan individually

Table 2 shows that lecturers carry out continuous learning activities at meetings 1 through 9. Phase 1: Motivate students to literate science and Phase 4: Evaluation and reflection are held at each meeting, but Phase 2: Guide the construction of science literacy is emphasized at meeting 1 only. This meeting is to provide direct experience to students to act as students in constructing science literacy through identification, exploration, explanation, application, and reflection activities. Phase 3: Produce and implement science literacy learning, at meetings 2-5 it is emphasized the production of science literacy lesson plan in groups, then continued by production of individual science literacy lesson plan at meetings 6-9. Students experience hands-on experience as teachers to examine the quality of science literacy lesson plan example provided, develop lesson plan in groups ans individually, implement it in peer-to-peer/simulation, then revised the lesson plan. Learning process was ended by post-test (O2). Each student was working on SLTS, and then continued by an in-depth interview with several students to clarify the problems that were found. The interview procedure includes: (1) selecting students who have n-gain of scientific literacy in low criteria (5 students), medium (5 students), and high (5 students); (2) conducting in-depth interviews toward all selected students; (3) Focusing Group Discussion to verify interview results; (4) summarizing the results of the interview.

Data Analysis

The data analysis is done as follows. The results of the science literacy test before and after following the learning process were calculated by using the scoring rubric in Table 3.

Table 3. Scientific literacy assessment rubric.

Science Literacy Test Sheet Items	Assessment Rubric	Score
1. Use science knowledge to explain scientific phenomena.	Mention the type of flat mirror.	1-0
	Describes the image properties on a flat mirror.	2-0
	Describes the process of thousand images mirror.	2-0
2. Use science knowledge for problem solving.	Identify known and unknown variables.	1-0
	Choose the right alternative solution.	2-0
	Resolve the problem so that the correct answer is obtained.	2-0
3. Use science knowledge to explain technology products.	Describe the connection with optical devices.	1-0
	Describes the connection with the formation of image on the lens.	2-0
	Describes its relation to refraction.	2-0
4. Decision-making.	Any answer choice is contact lenses or glasses.	1-0
	The explanations use physical knowledge.	2-0
	The explanation reckons the aesthetic point of view.	2-0
5. Distinguish scientific and unscientific questions.	Distinguish scientific and unscientific questions.	0-5
6. Identify scientific questions.	Questions raised according to the problem.	1-0
	Problems can be investigated.	2-0
	Each true question got 1 score 1. 2 true questions get 2 score. 3 or more true quesions get 3 score.	3-0
7. Design the exploration.	Hypothesis formulation.	2-0
	Identify variables.	3-0
	Create operational definitions of variables.	3-0
	Design data tables.	2-0
	Design an experimental procedure.	3-0
8. Transform data from one representation to another.	Create tables.	2-0
	Graphics.	2-0
	Analyze data.	2-0
	Draw a conclusion.	2-0
9. Analyze and draw conclusions appropriately.	Is the answer to the formulation of the problem / hypothesis.	1-0
	Expressed in the form of a statement.	1-0
	Created based on data observation / data analysis.	2-0
	Written briefly and clearly.	1-0

(Sunarti, Madlazim, & Wasis, 2017a)

The indicator score uses science knowledge to explain the phenomenon scientifically (items 1, 2, 3, 4); evaluate and design scientific inquiry (items 5, 6, 7); interpret the data and provide the scientific evidence (item 8, 9) are the total score obtained divided by the maximum score multiplied by 4. Furthermore, the acquisition score is adjusted to the criteria of science literacy assessment including 4.00 ≥ Very Good > 3.33; 3.33 ≥ Good > 2.00; 2.00 ≥ Sufficient ≥ 0.67; 0.67 ≥ Less (Minister of Education and Culture, 2014). The increased level of science literacy for pre-service physics teacher was analyzed by using n-gain. The n-gain value is determined by the equation: n-gain = (score post-test - score pre-test)/(maximum score - pre-test score) (Hake, 1998). According to the following criteria: (1) if n-gain ≥ .7 (high), (2) if .3 <n-gain <.7 (medium) and (3) if n-gain ≤ .3 (low). The choice of test method depends on the fulfillment of the normality assumption for pre-test score and post-test of the of pre-service physics teacher' science literacy. Whether or not an increase in science literacy of pre-service physics teacher is tested statistically with Paired t-test (parametric) or Wilcoxon test (non-parametric). Meanwhile, the magnitude of the improvement level is calculated based on the n-gain of the pre-service physics teacher' science literacy. The magnitude of consistency (no difference) level increase in student science literacy among the five groups was tested by using ANOVA or Kruskal-Wallis test. This test is done with the help of IBM SPSS 16.0 software.

Results of Research

Learning outcomes of all groups related to the student's science literacy are presented in Figures 1 and Table 4. Shape bar represent the mean of pre-test, vertical bar scores represent the mean post-test scores, and black bars scores represent the n-gain scores. Figure 1 shows the average post-test scores of student's science literacy for all groups is greater than the pre-test score. Figure 1 shows the average n-gain value of student's science literacy for group-1, group-2, group-3, group-4 and group-5 are respectively. .41; .46; .61; and .58. The average n-gain value of student's science literacy for all groups is in the modarate category. The average pre-test, post-test, and n-gain scores associated with the student's science literacy indicators for all groups are presented in Table 4.

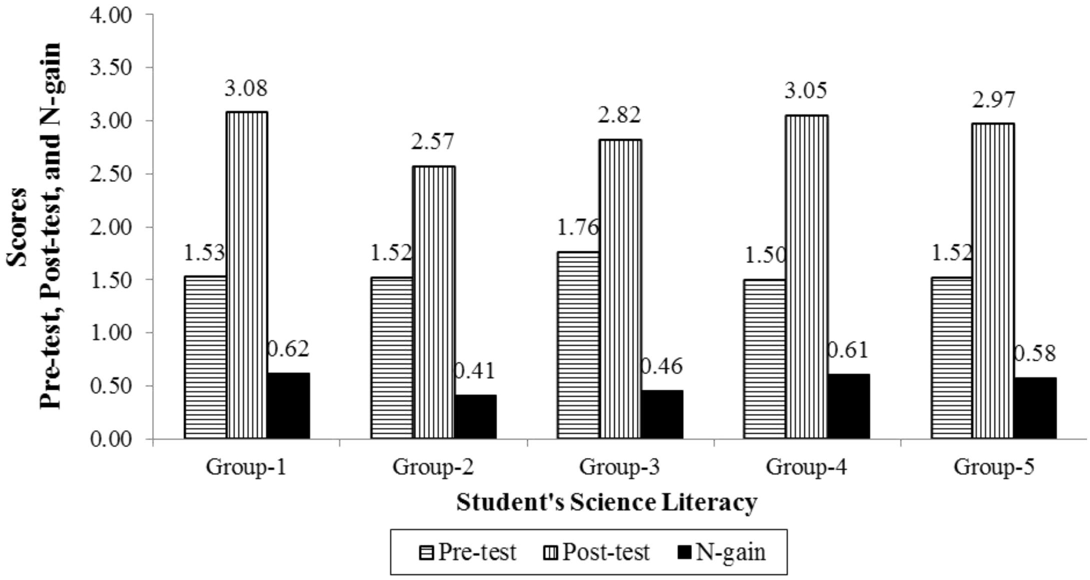

Figure 1: The mean of pre-test scores, post-test, and n-gain of science literacy in all groups.

Table 4. The mean pre-test, post-test, and n-gain scores of science literacy indicators for all groups.

Group	Scores	Science Literacy Indicator					
		Use physical knowledge to explain phenomenon scientifically		Evaluate and design scientific inquiry		Interpretat data and provide scientific evidence	
Group-1	Pre-test	1.78	Sufficient	1.41	Sufficient	1.38	Sufficient
	Post-test	3.21	Good	2.97	Good	3.09	Good
	N-gain	**.62**	**Medium**	**.60**	**Medium**	**.63**	**Medium**
Group-2	Pre-test	1.82	Sufficient	1.28	Sufficient	1.52	Sufficient
	Post-test	3.09	Good	2.03	Good	2.77	Good
	N-gain	**.56**	**Medium**	**.26**	**Medium**	**.42**	**Medium**
Group-3	Pre-test	2.17	Good	1.40	Sufficient	1.78	Sufficient
	Post-test	3.08	Good	2.53	Good	2.92	Good
	N-gain	**.49**	**Medium**	**.40**	**Medium**	**.51**	**Medium**
Group-4	Pre-test	1.79	Sufficient	1.32	Sufficient	1.39	Sufficient
	Post-test	3.13	Good	3.00	Good	3.01	Good
	N-gain	**.59**	**Medium**	**.63**	**Medium**	**.60**	**Medium**
Group-5	Pre-test	1.86	Sufficient	1.29	Sufficient	1.40	Sufficient
	Post-test	3.08	Good	2.95	Good	2.84	Good
	N-gain	**.56**	**Medium**	**.61**	**Medium**	**.54**	**Medium**

Note: Group-1 (Class A, Physics Education, Unesa); Group-2 (Class B, Physics Education, Unesa); Group-3 (Class C, Physics Education, Unesa); Group-4 (Class A, Physics Education, ULM); Group-5 (Class B, Physics Education, ULM)

Table 4 shows that students' early skills in using science knowledge to explain phenomena scientifically, evaluate and design scientific inquiry, interpret data and provid scientific evidence is sufficient (2.00 ≥ Sufficient > 0.67). After the application of the CPI teaching model, each indicator of science literacy increased to be good (3.33 ≥ Good > 2.00). The n-gain values for each indicator of science literacy in all groups were generally medium, except for the 2 groups on the indicators of evaluating and designing scientific inquiry which were in low criteria. The results of researchers' interview with some students showed that they were still difficulties in planning scientific investigations, especially formulating hypotheses, identifying variables, making operational definitions of variables, and designing experimental procedures appropriately.

The pre-test score and post-test of science literacy of pre-service physics teacher are normal and homogeneous distributions for the whole group. Therefore, the impact of learning with the CPI teaching model on increasing the science literacy of pre-service physics teacher for all groups using Paired t-test. The result of Paired t-test of science literacy is presented in Table 5.

Table 5. Results of Paired t-test science literacy of pre-service physics teacher for all Group.

Group	N	Paired t-test

		Mean	Std. Deviation	t	df	P
1	32	-1.56	.47	-18.65	31	< .01
2	32	-1.05	.45	-13.25	31	< .01
3	24	-1.06	.46	-11.37	23	< .01
4	32	-1.55	.40	-21.68	31	< .01
5	32	-1.46	.34	-24.11	31	< .01

Note: Group-1 (Class A, Physics Education, Unesa); Group-2 (Class B, Physics Education, Unesa); Group-3 (Class C, Physics Education, Unesa); Group-4 (Class A, Physics Education, ULM); Group-5 (Class B, Physics Education, ULM); *p < .05 (2-tailed)

Table 5 shows that the average science literacy for pre-service physics teacher for groups of 1, 2, 3, 4, and 5 was -1.56; -1.05; -1.06; -1.55; and -1.46. With degrees of freedom (df) = 31, 31, 24, 31, and 31; t score gave t value = -18.65; -13.25; -11.37; -21.68; and -24.11 for group-1, group-2, group-3, group-4, and group-5. The score is significant, because $p < .05$. Since the results of the calculations are of negative value, it is clear that there was an increase in science literacy of pre-service physics teacher after the application of learning with CPI teaching model for all groups. Furthermore, the consistency of the CPI teaching model application impact on the increase of science literacy of pre-service physics teacher was analyzed by using ANOVA after the assumption of normality and variance homogeneity.

Table 6. ANOVA conclusions of science literacy in all groups.

	Sum of squares	df	Mean square	F	p
Between groups	2.83	4	.71	1.23	.29
Within groups	172.05	299	.58		
Total	174.88	303			

Table 6 shows that F arithmetic gives $F = 1.23 < F_{table}\,(4.15) = 2.37$ with significance level $P = .29 > .05$. This clearly indicates that there is no difference in the increase of science literacy of the students after the application of CPI teaching model for all groups. Based on the results of data analysis above, it can be concluded that: (1) There is significant increase of science literacy of pre-service physics teacher (statistically) at the significance level of, $\alpha = 5\%$; (2) the level of science literacy improvement for pre-service physics teacher determined by normalized gain value (n-gain) is medium; and (3) the average level of science literacy improvement for pre-service physics teacher in the five groups did not differ significantly.

Discussion

The effectiveness of the CPI teaching model on the increase of science literacy of pre-service physics teacher in physics learning is seen from the increase of pre-test score and post-test of science literacy, n-gain science literacy value, and science literacy improvement which is no different in five groups (consistent) as shown in Figures 1 and 4-6. Before the application of CPI teaching model; pre-service physics teacher less masters the science literacy, average score of students science literacy was under standard score (score minimum 2.00 in range 1-4), that wass in group-1, group-2, group-3, group-4, and group -5 which are respectively 1.53; 1.52; 1.76; 1.50; and 1.52 (sufficient good category). At first, students have difficulties in using their physical knowledge to explain scientific phenomena, to evaluate and design scientific inquiry, to interpret data on complex life situations requiring high-level cognitive thinking (Table 4). The results of interviews with some students found some causes of the low literacy of their science are: (a) the process of physics learning is still emphasized on the understanding of concepts and mathematical problem solving, so that students are less involved in making decisions and solving real life problems; (b) scientific investigations carried out on individual practicum courses (basic physics lab, electronics, experiments); so that scientific investigation is less integrated in the learning process in the corresponding course; and (c) the lack of ability to plan and implement science literacy learning. This is consistent with previous research results that the mastery of science literacy of pre-service physics teacher from Unesa (Suliyanah, Putri, & Rochmawati, 2017; Sunarti, 2015; Sunarti, Madlazim, Wasis, Prahani, & Suyidno, 2017; Yusuf, Prabowo, & Prastowo, 2017) and pre-service physics teacher from ULM (Hartini, Zainudin, & Annur, 2012; Jamal & Suyidno, 2015; Suyidno, Dewantara, Nur, & Yuanita, 2017; Suyidno & Nur, 2015) are still low. Consistent with the findings of The Minister of Research and Technology of Higher Education (2014) that the limitation of opportunities for students in connecting physics knowledge in the classroom with real life, makes them less understand the essence of science literacy, moreover to develop science literacy learning. Conversely, after the application of CPI teaching model, the mastery of science literacy by pre-service physics teacher increased above the average and became good; the average science literacy scores for group-1, group-2, group-3, group-4, and group-5 were respectively 3.08; 2.57; 2.82; 3.05; and 2.97 (well beyond the minimum score of 2.00 in the 1-4 score range). The increase in student science literacy scores in all groups was significant and did not differ (consistent) at the 5% significance level with n-gain of .62 for group-1; .41 for group 2; .46 for group-3; .61 for group-4 and .58 for group-5. This indicates an increase in science literacy of pre-service physics teacher after being applied with CPI teaching model.

The increase of science literacy is supported by the availability of science issues that can inspire students to ask scientific and unscientific questions such as the scenario in phase 1: Motivate students to literate. In this phase, lecturers are also able to convince students to be positive in supporting the success of learning activities in each phase of the CPI teaching model. A positive attitude toward science makes learning more meaningful for students, become easier to learn science literacy, and relevant to their daily lives (Genc, 2015; Zain, Samsudin, Rohandi, & Jusoh, 2010). It is supported by cognitive theory that learning as a relatively persistent change in mental structure occurs because of the individual interactions with the environment (Moreno, 2010). Students are natural explorers who always try to understand the world by interacting with the environment and others. Self regulated learning theory that a process of setting personal goals of students; combined with motivation, thought processes, strategies, and positive behaviors can lead to the attainment of goals (Eggen & Kauchak, 2013; Sen, 2016). Students build a scheme, a mental operation that represents the world-built understanding to identify and understand new information based on past experience that has been preserved (Moreno, 2010: Slavin, 2011). The implementation of phase 1 is crucial to the success of the next phases.

The increase of scientific literacy is strongly influenced by phase 2: Guide the construction of science literacy in groups. Lecturers are able to facilitate pre-service physics teacher in constructing their own science literacy through identification, exploration, explanation, application, and reflection well. Students are involved in constructing science literacy through experimentation, problem solving, technology products, and decision-making related to science issues. This is supported by Vygotsky's constructivism theory that students actively construct science literacy knowledge through personal experience with others and the environment; Bruner's discovery learning theory that students learn when trying to find a solution to a problem or explanation of a phenomenon, not just memorize the rules or explanations submitted by the lecturer; and John Dewey's problem solving theory that the class becomes a laboratory for scientific inquiry and solving real-life problems (Moreno, 2010). Exploration which is equipped by scaffolding can increase scientific literacy and scientific inquiry (Brickman, Gormally, Armstrong, & Hallar, 2009; Gucluer & Kesercioglu, 2012). Scientific inquiry seeks to consolidate the process of inquiry with scientific knowledge, scientific reasoning, and critical thinking to form scientific knowledge (Wang & Zhao, 2016; Yilmaz & Kavaz, 2016). Scientific inquiry and multiple learning modalities support teaching and learning science literacy (Odegard, Haug, Mork, & Sorvik, 2015).

The increase of science literacy is supported by student's active participation in phase 3: Produce and implement science literacy learning. The novelty of the CPI teaching model versus the PBL, ITS, and IBL models lies in this phase; that is the students are not only being equipped with a positive attitude in constructing science literacy, but also knowledge and skills in planning and implementing science literacy learning (Moutinho, Torres, Fernandes, & Vasconcelos, 2014; Setiadi, 2013; Villaneuva, 2010). This phase supported the theory of metacognition skills that transferr what is learned to new situations will be increased as students become more self-conscious as active learners to monitor their own learning and knowledge strategies (Moreno, 2010). Another support of Vygotsky's social constructivist theory has four major implications: (a) social learning, students learn through interaction with more capable adults and peers; (b) Zone of Proximal Development; learn the best concept when the concept is in its nearest development zone; (c) cognitive apprenticeship; students gradually attain expertise in their interactions with a higher-knowledge master or peer; (d) scaffolding; students are given complex, difficult, and realistic tasks and then given sufficient help to solve their tasks (Moreno, 2010: Slavin, 2011). This is strengthened by Odegard, Haug, Mork, & Sorvik (2015) that science inquiry activities or multiple learning modalities support teaching and learning science literacy.

The increase of scientific literacy is also supported by the active involvement of pre-service physics teacher in phase 4: Evaluation and reflection. This is in line with the theory of distributed cognition learning that sharing ideas with others can improve the understanding of science literacy, being encouraged to clarify and organize their own ideas, elaborate, find weaknesses in reasoning, and enjoy alternative views that are as valid as they have (Moreno, 2010). It is reinforced by Ratcliffe (2012) that the development of science literacy can be done by requiring students to reflect on their own values and experiences, as well as to examine the objectives of the lesson to know the examination process (for example the decision making, evaluation of evidence) on science literacy content. Students are involved in the evaluation (learning science literacy through an assessment process of their own learning) and reflection (thinking process of thought and practice critically, learning from process, and applying what they learned to improve future actions) (Eggen & Kauchak, 2013; Moreno, 2010).

Based on the above description, the implementation of CPI teaching model proved to be able to increase the science literacy of pre-service physics teacher effectively, where the increase of science literacy of pre-service physics teacher for all groups is significant at 5% real level and consistent in the medium category. The effectiveness is supported by the characteristics of the CPI teaching model as follows: (a) the existence of science issues, presented science problems that inspire students to ask scientific and unscientific questions; (b) a positive attitude toward science, every student has the motivation and confidence in learning science, support scientific inquiry, and be responsible for resources and environment; (c) construct science literacy, students experience direct experience in identification, exploration, explanation, application, and reflection activities; and (d) the lesson plan product of science literacy and its implementation; students develop learning ideas through identification of the lesson plan examples of science literacy, discussions and consultations on the lesson plan development, implementation through peer-teeching/simulation, and the lesson plan revision. Other support is the CPI teaching model and learning tools including validity, availability of logistics needs, and professionalism of lecturers in teaching. This is reinforced by researchers' interviews with some students that they respond positively to: (a) the novelty of the learning atmosphere and the learning tools; (b) the teaching of science literacy is done systematically and could be easily understood; (c) students feel easy to act as a student when constructing science literacy; and (d) find it was easy to act as a teacher when producing science literacy lesson plan, implement peer-teaching, and revision of the lesson plan. The fundamental implication of this research is the CPI teaching model as the main alternative to increase the science literacy of pre-service physics teacher and can be widely applied to cultivate science literacy in the education world and in the life of society, nation and state.

Conclusions

The results of this study indicate that the CPI teaching model is effective to increase the science literacy of pre-service physics teacher based on: (1) the increase of science literacy of pre-service physics teacher significantly (before) and after the application the CPI teaching model at α = 5%; (2) the value of n-gain of pre-service physics teacher' science literacy in medium category; and (3) the mean n-gain of pre-service physics teacher' science literacy in all groups was not different (consistent). The main contribution of CPI teaching model in increasing the science literacy of pre-service physics teacher was the presentation of science issues, positive attitude toward science, science literacy construction, and product of science literacy lesson plan and its implementation. The application of the CPI teaching model is able to prepare professional pre-service physics teacher with scientific literacy content and pedagogical knowledge to plan and implement science literacy learning in the classroom. The implication of this research is CPI teaching model can be used as alternative to cultivate science literacy in educational world and in society, nation and state life. To reinforce the results of this study, further research is needed at various levels of education and country.

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