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THE DEVELOPMENT OF SCIENCE CPS (COLLABORATIVE PROBLEM SOLVING) LEARNING MODEL TO IMPROVE FUTURE ISLAMIC ELEMENTARY SCHOOL TEACHERS' COLLABORATIVE PROBLEM-SOLVING SKILLS AND SCIENCE LITERACY

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Abstract

The purpose of this ressearch is produce science learning material through guided inquiry model that valid, practical, and effective to increase collaborative problem solving skill and science literacy skill of student of Islamic primary school teachers. The development of learning material was tested in class student of Islamic primary school teachers 3rd semester Unipdu Jombang in academic year 2016/2017 since September - December 2016 with One group pretest-postets design. The data collection used observation method, test and quetionnaries. The data analysis techniqeus used descriptive analysis of quantitaive, qualitative and statistic non parametric. The result of this research are: 1) learning material developed has a valid category; 2) The practicality of learning material in terms of a good category in feasibility of lesson plans and the students activities in accordance with steps of CPS (Collaborative Problem Solving) model; and 3) the learning material effectiveness in terms of improving student learning achievement seen from the n-gain score with high category and improving Collaborative Problem Solving Skill and science literacy skill of student by getting the n gain score with high category and the student responds toward material and implementation of learning are very positive. It's conclusion that the learning material through guided inquiry model are valid, practical, and effective to increase science literacy skill of student of Islamic primary school teachers.

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INTRODUCTION

The recent globalization era is strongly influenced by the development of science and technology. Many problems in our daily life needs scientific information to solve them. Therefore, science literacy becomes a necessity for individuals to adapt with the dynamics of life. Along with the development of the period, technology and information develop quickly. Every people should be able to understand the knowledge of environment, health, economy, and other problems faced by modern society. Thus, scientific literacy is a must for everyone. Science literacy is a prerequisite to the development of the nation, specifically to the quality of human resources which literate to science and technology (Genc, 2015; UNESCO, 2008; Turgut, 2007; Turgut, 2005). It shows that science education expects the students to have science literacy which later can bring Indonesia to further development. Science literacy has become a wide concern for scientists, lecturers, and the enforcer of public policy (Putra, 2016; Impey, 2013).

Research regarding International students' science literacy is held by Organization for Economic Co-operation and Development (OECD) through Programme for International Student Assesment (PISA). Science literacy is deemed as the key of education for all students whether they will continue to learn about science or not (OECD, 2013:12).

Indonesian students' low literacy of science portrays that the country's education should be improved. From PISA's study, it is implied that people are demanded to follow the trend of the period. From the field facts, Indonesian students are clever to memorize things yet less skilled to apply their knowledge to solve problems. It may be related to the tendency of using memory as the platform of mastering science, instead of thinking skills. According to Toharuddin (2011), Indonesian science educators seems not clearly understand the development of conceptual learning.

Students' development of science literacy by teachers is an important challenge for higher education (Murcia, 2009). The survey in 1988-2008 shows that improvement of students' literacy in American's universities were less significant in the range of 10%-15% (Impey, 2013); it also happened to future teachers in Turkey (Akengin & Sirin, 2013).

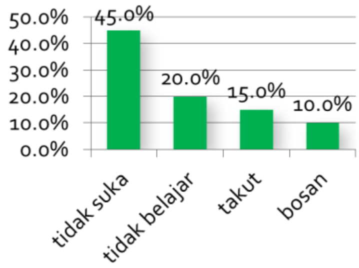

Figure 1. Graphic of Initial Study Showing Low Science Literacy of Islamic School Students' Science Literacy

The result of previous studies done by the researcher to 30 college students of Islamic Education Department in one of the private universities in East Java found many problems related to science literacy in the lecturing of science learning. The problems came from different background of the students, where 45% of them did not like natural science, 20% did not want to learn natural science, 15% was afraid to natural science, and 10% considered that science was boring. These negative perception led the students to have minimum interest to science which also led them to have poor results in science (Putra, 2016). These things showed that there is a problem of natural science teaching to future teacher. It is related to the process and the result of science lecturing. It means the future teacher of Islamic School generally does not understand the characteristics of ideal teacher, which are having conceptual, procedural, and epistemic understanding in consistent way to provide explanation, evaluation, and design to scientific discovery. The teacher should also be able to interpret data with variety of living situation which requires high cognitive level.

The development of literacy is highly needed to help these future teachers to understand science materials and its elements as wellas able to use appropriate learning method which can make them develop science literacy in the class (Udompong *et al.*, 2014). This development needs to concern that teacher should be given training of innovative learning which is applicable to be used by students in their daily life (Putra, 2016).

Research conducted by Harding & Griffin (2016), Griffin & Care (2015), Hesse *et al.,* (2015), Cress *et al.* (2015), Rosen & Mosharraf (2014), Rosen (2014), Greiff *et al.* (2013), OECD (2013), Greiff (2012) state that learning and scoring to collaborative problem-solving skills are important for elementary school students. As, they are demanded to work in group and implement the problem-solving skills to real social situations. The function and significance of collaborative problem-solving skills are: 1) an important capital for students to face global working fields' competition, 2) an alternative solution to solve problems individually in the learning process, and 3) a way to improve students' social skills in solving their daily life problems (Raesa, *et al.*, 2016; Prahani, 2016; Forte, 2015; Griffin & Care, 2015; Hesse, *et al.*, 2015; Care & Griffin, 2014; OECD, 2015a; 2013; Mercier, *et al.*, 2014; Schneider & Pea, 2014.; Tang, *et al.*, 2014; Nussbaum, *et al.*, 2014; Stahl, *et al.*, 2013).

The study of TIMSS and PISA on Indonesia's students problem-solving skills shows that the students are still in the low level (Martin, *et al.*, 2008; Martin, *et al.*, 2012; OECD, 2014; 2015b). This level does not mean that students are not clever enough to compete with other country; its means, the learning process does not meet the standard of tests used by PISA and TIMSS. It becomes an important thing to evaluate for the betterment of Indonesia's education.

A learning model with investigation and problem-solving features which can be applied for Elementary School students is CPS. This model is an alternative which can be developed to improve students' collaborative problem-solving skills and science literacy. It consists of six phases: (a) sharing perspectives, (b) defining problems, (c) identifying interest, (d) making choices, (e) determining objective criteria, and (f) evaluating choices and achieve agreement (Windle & Warner, 2000; Mercier & Higgins, 2014)).

Based on the explanation above, CPS is chosen to improve future elementary school teachers' collaborative problem-solving skills and science literacy. This research is entitled 'The Development of CPS (Collaborative Problem-Solving) Science Learning Model to Improve Future Islamic Elementary School Teachers' Collaborative Problem-solving Skills and Science Literacy".

Based on the background, this research focuses on "how is the validity, practicality, and effectiveness of CPS model as a science learning device to improve future Islamic elementary school teachers' collaborative problem-solving skills and science literacy?".

This research aims to produce valid, practical, and effective science learning device with CPS model to improve future Islamic elementary school teachers' collaborative problem-solving skills and science literacy.

METHODS

This research employed developmental approach. The researcher developed science learning tools based on CPS learning model to improve future Islamic elementary school teachers' collaborative problem-solving and science literacy. It was conducted from September to December 2016. The subjects of this research were 30 3rd semester students in Islamic Elementary School Education department which admitted to integrated natural science subject for Islamic elementary school students in the academic year of 2016/2017. This research used One–Group Pretest Postest design (Fraenkel, 2012).

Initial Test	Treatment	Final Test
O1	X	O2

The related variables to this research are as follows.

1. CPS (*Collaborative Problem Solving*) learning model
2. Validity of learning tools
3. Variables related to the practicality of learning tools, including:
    a. The feasibility of learning activity
    b. Students' activity
4. Variables related to the effectiveness of learning tools, including:
    a. Improvement of the students
    b. Collaborative problem-solving skills
    c. Science literacy skills
    d. Students' responses

RESULTS AND DISCUSSIONS

Learning process is basically the effort of teachers to help students learning to obtain knowledge (Barthelemy, *et al.*, 2015; Shubert & Meredith, 2015; Rudolph, *et al.*, 2014; Lin, *et al.*, 2013; Noroozi, *et al.*, 2013; Isjoni, 2010). Educators as the agent of innovative change should own the ability to guide students in conducting scientific investigation (Lu, & Ortlieb, 2009; Jan, et al., 2001). They should ideally understand natural science conceptually and comprehensively. They should be able to do qualitative or quantitative analysis as well as able to comprehend and develop students' multi representation, science literacy skills, and science inquiry; they should also able to anticipate conceptual difficulty experienced by students (Putra, 2016; McDermott, *et al.*, 2006; Heron, *et al.*, 2005; Kautz, *et al.*, 2005).

Collaborative Problem Solving (CPS) is developed by Department of Psychiatry at Massachusetts General Hospital (MGH) in Boston, Massachusetts. The first book describing this approach was published in 1998 (Pollastri, *et al.*, 2013). This model is the concept of behavioral externalization as the product of cognitive skills stored in the domain of problem solving, flexibility, and tolerance from frustration (Pollastri, *et al.*, 2013: 198). The result of the research found that the use of CPS with sequenced challenges to students are able to decrease opposing, forceful, and stressful behavior, resulting a betterment of individual skills (Martin, *et al.*, 2008; Pollastri, *et al.*, 2013). Collaborative Problem Solving (CPS) was developed by Mercier & Higgins (2014), Pollastri *et al*. (2013), Raleigh (2005). The scheme of the development is presented in Table 1.

Table 1. Syntax of Collaborative Problem Solving (CPS)

Phases	Information
1. Sharing perspective	Students use communicative skills to understand different perception from their situation, needs, and requirements.
2. Defining problems	Students emphasize topics and problems for discussion.
3. Identifying interest	Students identify their mutual agreement and interests.
4. Making choices	Students share their opinion and result ideas from the problems in different perspective prioritizing the alternatives of idea to enrich the solutions.
5. Determining objective criteria	Students solve problems using agreed criteria and reduce the choices.
6. Evaluating choices and meeting agreement	With the complete list of opinion and objective criteria, students evaluate choices and move to the agreement which will fulfill collective needs and interest.

(Sources: Windle & Warner, 2000; Mercier & Higgins, 2014)

CPS (Collaborative Problem Solving) has Plan A, B, and C (Pollastri, *et al.,* 2013).

1. Plan A is for the adults to force their intention and expectation to their children, despite it will stimulate children' externalizing behavior.
2. Plan B is used by adults to solve problems collaborating with their children.
3. Plan C is used by adults to expect, in short-terms to reduce externalization.

Collaborative Problem Solving (CPS) has been reviewed in some empirical studies. Rosen (2014) finds that from 179 students (88 males and 91 females, aged 14), 1) there is a higher possibility of conflict in human-to-human CPS (CPS emphasize the interaction between students) than in human-to-agent CPS (students' interaction to agent in computer (software) to propose solution, confirm solution, asking solution, and disagree to other's solution), 2) tasks assessment should be planned well that it will reach the success of completing task which requires cooperation and dependence among participants (Rosen, 2014: 22). The same research recommends that future research of Collaborative Problem Solving (CPS), needs to 1) conduct further research on communicating method and 2) concern on students' different achievement in solving different problems and methods of collaboration (Rosen, 2014).

Mercier & Higgins (2014) find that from the use of CPS to 96 students, 1) it is important to create collective space to external representation when being involved to collaborative problem solving and 2) it is required to effectively use the existing tools during the learning process. Further research needs to be done to investigate whether the training done by the member of the group in further collaboration becomes the productive way to support communal cognitives (Mercier & Higgins, 2014).

Hesse *et al.* (2015) discover that CPS will succeed if the member of the group can share multi representation to other member yet it should be directed and maximized in advance by teachers. The students should be given inquiry task by conducting experiment and work well with their group, where teacher consistently guides the students in the learning process.

Collaboration is a process involving participation of group of people coordinating and cooperating to plan, execute, and evaluate programs to reach a goal and solve problems with strong positive dependence (Diellenbourg, 1999; Diellenbourg & Traum, 2006; OECD, 2013; 2015a; Burns, *et al.*, 2014; Jones & Vall, 2014; Davis, *et al.*, 2015; Enyedy, *et al.*, 2015; Hesse, *et al.*, 2015; Rehm, *et al.*, 2015; Siqin, *et al.*, 2015; Stahl, 2015; Raesa, *et al.*, 2016; Prahani, 2016b).

Scientific collaboration is a scientific activity which can be done by one or more individuals, or small or big group (NRC, 2011). Social interaction is important in collaboration. Collaborative skills is measurable to individual and group contribution (Dillenbourg, 1999; Fiore *et al.*, 2010; Schwarz, *et al.*, 2015). In addition, collaborating activity is able to show better problem-solving skills than individual activity (Dillenbourg, 1999).

Collaborative learning and cooperative learning can be used alternatively, yet cooperative learning is more structured comparing to collaborative learning (Cooper & Robinson, 1998; Smith & MacGregor, 1992; Rockwood, 1995a, 1995b). Rockwood (1995a, 1995b) characterizes cooperative learning as an option to the development of basic knowledge, while collaborative learning is connected to science as a social construct. Based on the role of instructors, they become the center of authority in cooperative learning, leading the class with group exercises which have specific answers. Collaborative learning emphasizes on the authority of instructor to empower small groups which tend to be more open for complex tasks. In conclusion, collaborative skills is higher than cooperative skills (Prahani, 2016b; Cooper & Robinson, 1998; MacGregor, 1990; Smith & MacGregor, 1992).

Table 2. The Difference of Cooperative and Collaborative Learning

No	Cooperative Learning	Collaborative Learning
I	SIMILAR POINTS	
	1. Students value individual and group performance. 2. Students cooperate in group as their social skills are encouraged	
II	DIFFERENT POINTS	
	1. Students get training of social skills in small group activity. 2. Problem-solving skills activity was structured with fair distribution of roles to every student. 3. Teacher observes, hears, and intervenes the group if it is needed. 4. Cooperative learning is described as an 'order' in social process which always be connected	1. There is a belief that students already had the social skills which they need to build for the sake of learning objectives. 2. Students in group (min. 2 people) regulate and negotiate together in solving open and complex problems. 3. Collaborative learning does not have to be monitored by instructor/teacher. When a question is directed to teachers, they only guide the students to obtain the required information. 4. In collaborative learning, students are emphasized to build an open-ended knowledge or problems which is later distributed to all groups to solve or share. 5. Collaborative learning is more open and controlled by students. 6. Collaborative learning has more mechanism and introspection analyzing team which is centered to students.

No	Cooperative Learning	Collaborative Learning
	and related to reach goals of closed-ended tasks. 5. Cooperative learning is more directive and controlled by teacher. 6. Cooperative learning has mechanism and introspection analyzing team which is centered to teacher while the collaborative learning tends to be fully student-centered	

(Sources: Cooper dan Robinson, 1998; MacGregor, 1990; Smith dan MacGregor, 1992; Matthews, *et al.*, 1995; Rockwood, 1995; Dillenbourg, 1999; Panitz,1996; 1999; Moreno, 2010; Woolfolk, 2010; Hesse, *et al.*, 2015; Ludvigsen, *et al.*, 2015; Prahani, 2016b).

Table 3. Scoring Rubric of Collaborative Problem-Solving Skills

No	Collaborative Problem-solving Skills	Operational definition	Scoring aspects
1	Task regulation	Students can understand and assess the problems by identifying concept/principles/theories/law of physics, physical quantities, and identifying prompted quantities as collaborative problems.	1. Students can identify concepts/principles/theory/law of physics in collaborative problem-solving. 2. Students can identify physical quantities which is known for collaborative problem-solving. 3. Students can identify prompted physical quantities for the collaborative problem-solving.
2	Perspective talking	Student can accept and contribute to create a logical drawing containing direction of collaborative problem-solving.	1. Students can make a logical drawing/diagram containing direction of collaborative problem-solving. 2. Students can make drawing/diagram which can contribute to collaborative problem-solving. 3. Students can make a drawing/diagram by accepting direction from other people for collaborative problem solving.
3	Learning and Knowledge Building	Student can make a strategy of problem-solving in the terms of steps to collaborative problems (conceptual strategy) logically and systematically.	1. Students can make logical strategies of problem-solving. 2. Students can make systematic strategies of problem-solving. 3. Students can face and solve

No	Collaborative Problem-solving Skills	Operational definition	Scoring aspects
			collaborative problems
	Participation	Students involve actively in implementing collaborative strategies to solve the problems (execute the solution) systematically.	1. Students actively involve in implementing strategies to solve collaborative problems. 2. Students implement the strategies to solve problems systematically. 3. Students get the appropriate solution/resolution from the implementation of the strategies.
	Social regulation	Students can do reflection from the probess and result of collaborative problem-solving (Sum up your learning).	1. Students can do self-reflection to their improvement in collaborative problem-solving skills. 2. Students can do self-reflection to their lack which can be improved in collaborative problem-solving skills. 3. Students can do self-reflection to their strength which can be maintained/improved in collaborative problem-solving skills.

(Adapted from Care, *et al.*, 2015; Docktor, 2009; Hesse, *et al.*, 2015; Teodorescu, *et al.*, 2014 Prahani, 2016b)

Table 4. Rubrics of Science Literacy Skills

No	Science literacy skills	Level
1	Students can describe scientific inquiry method and implement the investigation, asking, and solve problems	**Beginner** a. Students cannot identify scientific problems. b. Students do not understand problem-solving. c. Students cannot define hypothesis.
		Intermediate a. Students can identify scientific problems b. Students can choose a solution of problems c. Students can define definition
		Advance a. Students can retell the statement of the problems b. Students can predict one or two solutions c. Students can make hypothesis
		Expert a. Students can develop research questions b. Students can evaluate different alternative of solution c. Students can propose evaluation of

No	Science literacy skills	Level
		hypotheses
2	Students can describe the procedures and steps of experiments	**Beginner** a. Students do not understand the objective of the experiment b. Students cannot determine the required equipment during the experiments c. Students do not understand variables of experiment
		Intermediate a. Students can express the objective of the experiment in their own words b. Students can determine the materials of the experiments c. Students can distinguish dependent and independent variable
		Advance a. Students can express the objective of the experiment in their own words b. Students can determine the materials of the experiments c. Students can distinguish dependent (control) and independent (manipulated) variable d. Students can describe the connection between procedures of experiment
		Expert a. Students can express the objective of the experiment in their own words b. Students can determine the materials of the experiments c. Students can select dependent (control) and independent (manipulated) variable d. Students can manipulate dependent (control) and independent (manipulated) variable e. Students can manipulate the design of the experiment
3	Students can present their exercises of practicum correctly and precisely	**Beginner** a. Students do not know the safety procedures to use lab tools b. Students do not know the procedures of report writing c. Students cannot identify science tools d. Students cannot work independently
		Intermediate a. Students can follow the safety procedures to use lab tools b. Students know how to write science report accurately c. Students can use scientific tools with the

No	Science literacy skills	Level
		most appropriate technique d. Students can measure and collect data
		Advance a. Students can follow and implement the safety procedures to use lab tools b. Students know how to write science report accurately c. Students can use scientific tools with the most appropriate technique d. Students can measure and collect data with minimum mistakes
		Expert a. Students take initiatives to follow safety lab procedures b. Students take initiatives to write science report accurately c. Students take initiatives to use scientific tools with the most appropriate technique d. Students take initiatives to measure and collect data accurately
4	Students can interpret and communicate scientific information in verbal, written, and graphical data	**Beginner** a. Students cannot interpret information quantitatively from table and graphic using simple sentences
		Intermediate a. Students can interpret quantitative information from table and graphic using the most appropriate sentences b. Students can construct data from table and represent the information in graphic
		Advance a. Students can interpret information quantitatively from table and graphic using the most appropriate words b. Students can independently construct data from table and represent the information in graphic c. Students can communicate the result of experiment and investigation
		Expert a. Students can interpret quantitative information accurately using sophisticated words and correct inference b. Students can independently construct data from table and represent the information in graphic c. Students can communicate the result of experiment and investigation clearly d. Students can draw logical conclusion

No	Science literacy skills	Level
		based on the collected data
5	Students can describe and analyze one or more technological science along with the society and demonstrate scientific understanding in daily life application	**Beginner** a. Students tidak dapat mengidentifikasi terobosan teknologi dan hubungannya dengan sains
		Intermediate a. Students can identify technological breakthrough in relevance to science b. Students can identify the historical breakthrough of the technology c. Students can explain the impacts of technology to the society
		Advance a. Students can identify technological breakthrough in relevance to science b. Students can identify the historical breakthrough of the technology c. Students can explain the impacts of technology to the society d. Students can explain one or more principles of scientific technologies
		Expert a. Students can identify technological breakthrough in relevance to science b. Students can identify the historical breakthrough of the technology c. Students can explain the impacts of technology to the society d. Students can explain one or more principles of scientific technologies e. Students can exemplify the development of future science technology in the society.
6	Students can explain natural phenomena with logical understanding, experiment steps, or applying concepts of science and technology	**Beginner** a. Students can hardly identify logical explanation logical explanation of science phenomena
		Intermediate a. Students can identify logical explanation of science phenomena b. Students can identify the misconception and illogical conclusion based on observation
		Advance a. Students can identify alternative logical explanation to science phenomena b. Students can identify the misconception or illogical conclusion based on observation or data
		Expert a. Students can develop alternative logical

No	Science literacy skills	Level
		explanation based on science observation b. Students can identify the misconception or illogical conclusion based on observation or data. c. Students can evaluate questions based on observation, experiment, or data

(Adapted from: Putra, 2016; OECD, 2013)

From Table 4, there are 6 science literacy skills which have four levels (Putra, 2016; OECD, 2013). People's science literacy skills are different based on their understanding before, during, and after the learning process and students' ability to associate their understanding with other concept or situation.

Some findings were found on this research were according to the analysis of data during the learning process. The findings were as follows.

- The validity of learning tools can be seen from the validity of lesson plan, college students' worksheet, learning materials, scoring instruments (behavior scoring instruments, knowledge assessment, working performance test), collaborative problem-solving tests, and science literacy tests. The learning process of science with CPS need to develop collaborative problem-solving skills and science literacy was developed and validated for the learning process.
- The practicality of science learning process is developed through the implementation of experiment I as follows.
- The execution of the lesson plan to third semester students of Unipdu Jombang with two replication scored 3.85 in good category.
- Students' activity was experimented based on the steps of CPS. The most emphasized activities were planning, conducting experiment, and analyzing the data of the experiment.
- The effectiveness of the learning tools through experiment I can be seen as
- The application of the learning tools with CPS could improve students' learning outcome with 1) the average n-gain of knowledge was 0.88 in high category, 2) the average n-gain science processing skills was 0.79 in high category and the n-gain of psychomotor was 0.85 categorized as high, and 3) the feasibility of every aspect was good.
- The implementation of CPS science learning could improve future elementary school teachers' collaborative problem-solving skills. It can be seen from the n-gain of third semester students of Elementary School Education Department which obtained the n-gain average score of 0.85 or high category.
- The implementation of the learning model could improve students science literacy skills with the average n-gain score of 0.88.
- Students' responses were very positive to the development of CPS for science learning with 88.4% of them respond it as very strong.
- The obstacle of the students who had minimum academic skills also had low collaborative and science literacy skills as they were not familiar to CPS which used psychomotor laboratory activity.

CONCLUSION

From the results and discussion, the use of CPS (Collaborative Problem Solving) in Science learning was proven valid, practical, and effective to improve future Islamic elementary school students' collaborative problem-solving skills and science literacy skills.

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