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DESIGNING SCIENCE LEARNING FOR TRAINING STUDENTS' SCIENCE LITERACIES AT JUNIOR HIGH SCHOOL LEVEL

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ABSTRACT

Science literacy is an important knowledge comprehended by a person living in a society. Afterward, he actively elucidates several problems in wise ways. Science literacies also viewed as knowledge domains and competence domains are currently used by people to solve problems and to make decisions. In an ideal science learning perspective, the activity should facilitate students to exercise science literacies. However, science learnings implemented at some schools in Bandung have not facilitated science literacies yet. For example, the experiment activity adopted in these schools commonly uses a cookbook type. Consequently, teachers usually fell hard in developing questions focusing on a science literacy topic. In addition, the students' working papers still implement a cookbook type verifying science evidences. The first year result of descriptive research using a cross-sectional descriptive survey method for 628 samples at five schools in Bandung shows two profiles of science literacies. At the knowledge domains, students have comprehended 61.4% content knowledge, 52.8% procedural knowledge, and 46.2% epistemic knowledge. At the competence domains, 54.6% students can describe science phenomena clearly, 53.2% students can plan and evaluate the research, and 49% students can interpret data and scientific evidences. By analyzing their science literacy profiles, examining teachers' lesson plans, and interviewing teachers and students, the science learning designs have been reconstructed through making lesson plans. This design is developed in order to focus on locally and globally contextual knowledge recognitions. The training of actual science concept descriptions explaining science phenomena, the inquiry science experiment guidance training a procedural knowledge, a questioning competence, and an experiment design have been included in a teacher's lesson plan. This research implied that the student's competences in making a decision, evaluating an investigation process of science evidences and science literacies in a global context should be prepared.

Keywords: Science Literacy, Learning Reconstruction, Knowledge Domain, and Competence Domain

INTRODUCTION

Science literacy is defined as a competence in comprehending science and its applications for human necessity (DeBoer, 1991). The science literacy is also considered as the knowledge, a concept comprehension, and a scientific process skill. In daily life, this literacy is needed to make a decision, to participate in social-culture, and to increase the economical productivities (NRC, 1996). As the scientific knowledge, the science literacy is ordinary used to identify science questions, to obtain novel knowledge, to describe science phenomena, and to make conclusions based on the evidences (Firman, 2007). Somebody possessing science literacy will be able to read, to understand, and to have responsibilities in handle his daily life problems (Keefe, 2011 and Claugh, 2013). Therefore, science literacy is one of the important objectives that should be achieved in a science instruction (OECD, 2013 and Wenning 2006). Another reason as given in Indonesian's science instruction curricula is that a student have to be engaged to comprehend and to apply his knowledge, so he can solve his problem by himself and he strives to create his original ideas (DeBoer, 1991).

Science literacy is viewed as an important skill notwithstanding, the experiment activity in a science instruction conducted by cookbook model is not directly facilitating in guiding science literacy. The PISA

(Programme for International Student Assessment) data reinforcing this investigation at 2012 shows that the Indonesian students' percentages in comprehending science literacy are 41.9% at level 1 and 24.7% at below level 1 (Fleischman, 2010). This data shows that some of the Indonesian students have difficulties in applying their knowledge. They only have common knowledge that only can be applied in ordinary situations. Hence, the particular investigations identifying the students' difficulties should be firstly prioritized (Udompong, 2013). However, the research has not yet connected to lesson plan directly and its alternative actions to train the science literacy. The research will attempt to prepare lesson plan in instructing science literacy based on the analysis of students' difficulties on science literacy.

There are four domains of science literacy as given by PISA framework 2015 (OECD, 2013). First, context domains are related to the personal problem, local problem, and global problem. Second, competence domains are describing science phenomena, evaluating and planning scientific research, interpreting data and scientific evidences. Third, knowledge domains are related to content knowledge, procedural knowledge, empirical knowledge. Finally, attitude domains are related to students' interest in science and technology, assessing scientific approaches in science investigations, and students' perception as well as their awareness on environmental problems. In this research, the profile of students' difficulties on science literacy is limited to the competence domains and knowledge domains. The lesson plans are designed for 5 topics including (1) temperature and thermal expansion, (2) heat and phase exchange, (3) kinematics, (4) energy, and (5) static electricity. This qualitatively descriptive research begins with making the instrument of science literacy test. Afterward, the students' science literacy profile will be described. Students and teachers will be interviewed. Moreover, the existing school's lesson plan will be analysed. The result will be used as the consideration in constructing science literacy-based lesson plans.

METHODS

The descriptive research will be conducted using cross-sectional survey method. The profiles of students' science literacy during science learning will be analyzed through direct observation compared to the literature study (Creswell, 2012). The number of the students participating in this research is 628 students come from five different schools. The samples are randomly chosen using Taro Yamane equation as given in Eq. (1) (Puszczak, 2013).

$$n = \frac{N}{1+Ne^2} \tag{1}$$

where n = sample numbers, N = targeted population numbers, and e = confidence level used is 0.5. To analyzed the quality of lesson plan, the research instruments are constructed following several standards including science literacy tests referring to knowledge domains as well as competence domains of PISA framework 2015. Each domain is tested by 18 questions containing content questions, procedural questions, and epistemic questions. The questions testing students' competence in describing science phenomena, students' competence in research plan and its evaluation, students' competence in science interpretations are also included in the questions. The test instrument is validated using moment product at the range between 0.45 and 0.7 categorized as adequate result and good result, respectively (Arikunto, 2010). Subsequently, the test reliability is examined using KR-20 method comparing $t_{measurement} > t_{table}$ fulfilling reliable criteria 0,65 > 0,34.

Teachers and students are interviewed to obtain the information regarding actual learning process. The manual of interview process is judged by triangulation technique. To demonstrate science lesson plan constructed by a teacher, the lesson plan will be analyzed using iterated reliability technique proposed by Posner, Sampson, ward dan Cheney (Selçuk, 2008) as shown in Eq. (2).

$$R = \frac{number\ of\ agreement}{number\ of\ agreement + number\ of\ disagreement} x100\% \tag{2}$$

Table 1 shows the interpretation of science literacy profile calculated from Eq. (2) (Arikunto, 2010).

Table 1. Interpretation of Science Literacy Profile

R (%)	Interpretation
80-100	Very good
66-79	Good
56-65	Adequate
40-55	Poor
0-39	Very Poor or Failed

RESULT AND DISCUSSION

Science Literacy Profile

In accordance with the science literacy result tested at the 5 schools, the knowledge domain profile has been found as listed in Table 2.

Table 2. Knowledge Domain Profile

No	Knowledge Domain	R (%)	Interpretation
1	**K1**: Content	61.4	Adequate
2	**K2**: Procedural	52.8	Poor
3	**K3**: Epistemic	46.2	Poor

Content knowledge is knowledge application, which is relevant to the real situation. Interestingly, students are good enough in applying their content knowledge. In this case, students can express the displacement of a man climbed up a mountain given from a certain figure.

Procedural knowledge explores students' knowledge in designing scientific investigation based on questions of scientific inquiry. Nonetheless, this knowledge has been poorly possessed by students due to the following reasons. First, students feel hard in planning the strategy to scientifically control a dependence parameter. Whereas, this parameter contributes to determine their research quality directly. Second, the research planning following scientific inquiry questions is not easy to be constructed by students at the instance they have to check the quality of vegetable oil according to its density. Subsequently, they must determine the dependence and independent parameters. Moreover, students are also given a challenge to increase the spinning of waterwheel by changing a particular independent parameter. Finally, they continue to arrange an observation table from the experiment procedure.

Epistemic knowledge is related to the students' knowledge in defining scientific aspect and justifying data scientifically. However, according to the result, the students' epistemic knowledge is poorly categorized. The result will affect to the students' weaknesses in arranging scientific reasons such as a deductive reason, an inductive reason, an abductive reason, and an analogical reason. Moreover, students will have difficulties in modeling science phenomena, claiming science scientifically based on the data, and developing novel knowledge scientifically. For instance, the students are rather difficult to determine the quality of thermos bottle as a teacher is providing a graph of temperature change during storing water.

Table 3. Competence Domain Profile

No	Competence Domain	R (%)	Interpretation
1	**C1**: Describing science phenomena	54.6	Poor
2	**C2**: Planning and evaluating research	53.2	Poor
3	**C3**: Interpreting data and scientific evidences	49.0	Poor

Table 3 shows the profile of competence domain tested to 5 schools. The students' competence on describing science phenomena is poorly classified. Whereas, the competence is directly connected to making and justifying a prediction. In case of students' activities during science learning, students predict a pendulum position possessing the highest speed when a pendulum is swinging. Likewise, students briefly guess the ice melting either wrapped by a piece of paper or bare condition.

Competence domain category on planning and evaluating research is poor. Whereas, the domain measures the students' competence on research evaluation and making scientific inquiry questions (Gormally, 2009). For example, a teacher is showing a free-falling object onto wheat flour surface. By observing the phenomenon, a student will be asked to make appropriate questions investigating concepts of a free-falling object as well as its reflection. Moreover, the competence is commonly used by researchers to ensure reliabilities, objectivities, standard interpretation of measured-data. In case of radiation concept, students construct the experiment to understand the heat transfer through radiation as shown in Fig. (1). Students afterward evaluate this experiment procedure.

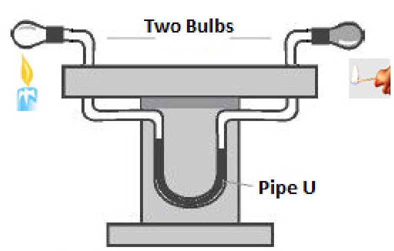

Figure 1. Experiment set up on the topic of radiation

Competency domain on interpreting data and scientific evidences is poorly comprehended by students. This competence evaluates students' ability in analysis, data interpretation, and making a conclusion after a particular problem is provided to students. In this case, data of the energy utilization is given to students, and they have to classify some energy sources into the group of renewable energy as well as the non-renewable energy (Hobson, 2003). On the other hand, students are also asked to make a conclusion based on the graph analysis of matter-absorbed heat towards temperature increase.

Lesson Plan Analyses

Although some schools use either KTSP or K13 curricula even now, some learning stages adopted from these curricula can be considered as the stages training science literacy as tabulated in Table 4. According to the rubrics developed for analyzing lesson plans as well as interview descriptions conducted to teachers and students, the lesson plans obtained from some schools have been analyzed.

According to the lesson plan analyses, the unsurprising results of both knowledge domain and competence domain are influenced by a lesson plan, which has not facilitated science literacy-based science learning yet. Consequently, science literacy activities should be inserted into science learning for both KTSP and K13 curricula in order to directly improve the human quality of

Table 4. The analyses of actual schools' lesson plan training science literacy

Learning Stage Structures		Trained Science Literacy Domains	Findings
Curriculum KTSP	**Curriculum 2013**		
Introduction			
Apperception		K1, C1	Apperception is currently viewed as knowledge requirement
Motivation		C1	
Cognitive conflict / Showing science phenomena	*Observing* Inferential activity introduced from direct observation to collect data and to initiate scientifically-investigated questions	K2,C1,C3	The stage has not yet offered questions regarding contextual problems specifically explored as local context, personal context, or global context. Giving learning purposes have not generally provided the benefits that will be achieved by students after studying science. The cognitive conflicts offered to students have not corrected any students' misconceptions yet.
Problem	*Questioning* Predicting the relationship between two parameters	K2,C1,C2	Science phenomena are commonly shown through video demonstrations. Whereas, there are many phenomena, which can be simply demonstrated through hands-on activities such as conduction phenomenon. Consequently, the students' observation does not directly consider to inspected questions
Main learning stage			
Exploration	*Making experiment procedures*	K2,C1,C2, C3	Students are not joined directly in making experiment procedure beginning with writing predictions, determining hypothesis, and understanding appropriate experiment procedures. The students' worksheets commonly explain science experiment adopting a cookbook model.
Elaboration	*Doing experiment*	K2,C2	Students completely follow the experiment procedures provided from students' worksheet. There are a lot of experiment activities, which do not have standards of both process and equipment.
Confirmation	*Analyzing data and Composing conclusions*	K3,C2,C3	Some lesson plans show the students' activity in composing a conclusion.
	Communicating experiment result		There are not enough facilitates to evaluate the students' investigation results.
Closing stage			
Reinforcement			The stage is well-conducted emphasizing key concepts needed for students.

	Samples of science application	K1	Questions usually offer simple physics problems analyzed through the mathematical calculation.
Evaluation	*Doing a task on the topic of creating novel innovation*	K1,K2,K3 C1,C2,C3	The exercises given to students still use available questions offered on text books. Questions still examine students' ability in recalling learning materials such as remembering science concept, using related science formulas as depicted on text books. The lesson plan did not explicitly appraise students' attitude such as their honesty. Rubrics of student's attitude and student's activity are rather difficult to be implemented at a large class.

potential Indonesian students not only for their future life but also for student's achievements themselves.

Some teachers have some difficulties in interpreting contextual science phenomena and conducting its science concept in accordance with the interview results. Consequently, several additional courses on the topic of popular sciences should be facilitated. This learning materials can be obtained from some media such as internet, e-book, encyclopedia, and gadget. The utilizations of these media can handle teacher's problems (Hobson, 2003). The locally contextual problems should be explored in order to train students' science literacy (Anjarsari, 2014). In addition, students should be motivated to apply their concept in solving problems on personal contexts as well as global contexts. For example, how students can apply their science concept to be a winner on a marathon run contest.

Cognitive conflict can be demonstrated by a teacher if only he investigated some misconception, that will appear from students' thinking. To predict students' misconception, a teacher should read articles regarding misconceptions specifically from science. The conflict cognitive given will decrease students' misconception instead of improve students' ability in describing science phenomena (C1), analyzing, and evaluating data scientifically (C3). For example, a conflict cognitive can be confirmed through understanding students' thinking on the concept of floating object, flying object, or sinking object whether it is due to its object's density or other parameters influencing this object. This activity can be expected in order to emphasize student's attention during learning science.

Observation activities training K1, C1, and C3 require a teacher-questioning skill to construct an inference investigated from science phenomena. All of the students' sensory organs should be obviously involved in science learning. In a scientific approach, observation activities should investigate science phenomena through questioning process. At the beginning study, students fell difficult in giving particular science questions, but a teacher can model questioning activities to be answered by students.

An inquiry experiment activity can be conducted by students to improve their science literacy rather than conducting a cook book-type experiment. The higher level inquiry activity can improve students' intellectuality significantly (Wenning, 2006). To handle students' difficulties, the should be accustomed to using inquiry model helped by a teacher during conducting science experiment. The level of inquiry can be explored in order to train inquiry process conducted by both students and a teacher (Banchi, 2008).

The evaluation process and making a decision based on students' analysis can be done during science learning if only a teacher prepare a science instruction well. Students should consider that science experiments conducted at school are simplified phenomena ordinary happened at nature, so many factors will influence the result. Therefore, students can model nature phenomena during science investigations while a teacher can investigate students' abilities in evaluating their experiment and making decisions related to domains of both C3 and K3 (Creswell, 2012).

CONCLUSIONS

Students' science literacy profiles have been investigated. On the knowledge domains, the category of content knowledge (K1) is good enough while the category of both procedural knowledge (K2) and epistemic knowledge (K3) is poor. Moreover, the competence domains are poorly classified for all categories including describing science phenomena (C1), planning and evaluating research (C2), and Interpreting data and scientific evidences (C3).

The learning reconstruction has been designed through constructing science learning stages. On each stage, science literacy domains have been investigated through emphasizing contextual problems regarding personal context, local context, or global context. The real science phenomena should be shown in order to improve students' abilities in applying science concepts and evaluating their experiment. The inquiry experiment can be proposed to train students' competences on procedural knowledge, questioning skills, and constructing science experiments. The modelling of making decision and evaluating science investigation process conducted by students is essentially required. The scientific evidence and data are needed during the inquiry process in order to support students' science literacy on the global context. The research implied that the research instrument assessing science literacy should be compared to standard tests of science literacy so that both test validity and its reliability can be highly improved.

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