

**SCIENCE LEARNING IN PRIMARY SCHOOL IN THE PERSPECTIVE OF
NATURE OF SCIENCE: A CASE STUDY IN THE FIFTH GRADE****Linda Hania Fasha¹**¹ IKIP Siliwangi¹ lindahania@ikipsiliwangi.ac.id**Abstract**

The case study of elementary school science learning is performed in the fifth grade of a primary school located in Bandung. The study aims to describe the extent to which the nature of the sains principle is identified through classroom learning. In this study, the data used include the document of learning draft, teacher's point of view towards science and its learning, learning activities documentation, and school principal's point of view about learning in general including the expectation towards science learning. In terms of the main objective of science learning, students' initial ideas about science triggered in the context of learning problems used can be explored properly through answers to questions raised by the teacher as well as students' conclusions or statements on the studied problem. The study has successfully identified seven aspects of the nature of science in learning, although the depth and wholeness of these aspects still need further development in the future. Based on the result of the study, it is concluded that a progressive effort is still needed to improve teachers' beliefs system and their learning.

Keywords: Nature of science, science process skills, teachers' beliefs system

Abstrak

Studi kasus pembelajaran sains sekolah dasar ini dilaksanakan di kelas lima Sekolah Dasar di Kota Bandung. Penelitian ini bertujuan menggambarkan sejauh mana prinsip hakikat sains teridentifikasi dalam pembelajaran di kelas. Data yang digunakan meliputi dokumen rancangan pembelajaran, pandangan guru tentang sains dan pembelajarannya, rekaman aktivitas pembelajaran, dan pandangan kepala sekolah tentang pembelajaran secara umum serta harapannya tentang pembelajaran sains. Ditinjau dari tujuan utama pembelajaran sains, ide-ide awal dari anak tentang sains yang dipicu konteks masalah pembelajaran yang digunakan, dapat tereksplor dengan baik ditunjukkan melalui jawaban atas pertanyaan yang diajukan guru serta kesimpulan atau pernyataan anak atas masalah yang sedang dikaji. Penelitian ini berhasil mengidentifikasi tujuh aspek hakikat sains dalam pembelajaran, walaupun kedalaman serta keutuhan aspek hakikat sains masih perlu dikembangkan lebih lanjut. Hasil penelitian juga menyimpulkan bahwa masih diperlukan upaya lebih progresif untuk memperbaiki sistem keyakinan guru tentang sains dan pembelajarannya.

Kata Kunci: Hakikat sains, keterampilan proses sains, sistem keyakinan guru

INTRODUCTION

Science learning in primary school has strategic roles in raising awareness about nature including its empowerment and preservation. This awareness is highly important for young generations as they will be responsible for preserving nature in the future (Tytler, 2010; Lamanuskas, 2009). Nature is God-made with its limitation, thus preservation and empowerment issues should turn to be a positive cultural attitude of society. Without collective awareness, the future generation will encounter fundamental difficulties with at least three types of crises, namely energy crisis, food and occupancy crisis, and natural environment crisis. These problems become collectively responsible for society including the education

circumstance. Therefore, the awareness towards natural environment crises has to be raised as early as possible through the education process including a primary school.

Even science education is viewed as important and strategic for human life, though in practice many problems are found. It is depicted by the result of the study performed by PISA (the Programme for International Student Assessment) showing that many students in several countries have low interest in learning science (Thomson & De Bortoli, 2008). On the other hand, the traditions of science learning widely developed at school, including primary school, tend to be more oriented to implement knowledge transfer activity and its context is irrelevant to daily life (Aikenhead, 2006). Aikenhead also found in his study that the effort in developing science learning which concerns more on the nature of science principles is not considered as a serious remark yet. This fact is represented by the previous study held in one of a primary school located in Bandung. The analyzed data of the previous study is obtained from the documentation of science learning about electricity recorded in the fifth grade.

Concisely, nature of science, according to Harlen and Qualter (2004), comprises eight aspects as follows:

(1) Scientific investigation using the varied method, (2) Scientific knowledge based on empirical evidence, (3) Scientific knowledge is open for revision, (4) Scientific model, law, mechanisms, and the theory explains the scientific phenomenon, (5) Science is a way to understand, (6) Scientific knowledge assumes an organized and consistent system, (7) Science is human's effort, (8) Science always give questions about nature and the world. Those eight aspects of the nature of science are important references in science learning, including in primary school, with several premises. First, the development of science learning for children needs to be undertaken through an effective process so the learning experience can provide a deep meaning about the natural phenomena and raise awareness and wise attitude. Second, the learning experience through a proper science process, as expected like science, can stimulate scientific thinking skills which are very useful for life as well as the further learning experience. Third, the experience of science learning which considers the principles of nature of science potentially impacts students' awareness about the position and role of a human being in empowering nature's potential as well as the preservation effort.

According to the above background of the study, the formulation of the problem is as follows: "What is the profile of science learning in primary school, in terms of the principles of the nature of science?" Since the research is conducted in the fifth grade of Gagas Ceria Primary School Bandung, the formulated problem is elaborated into the following questions:

(1) What are the characteristics of learning plan in terms of principles of nature of science? (2) What is the teacher's view of the nature of science and its learning? (3) What are the characteristics of the science learning process? (4) What are the principal's views and expectations about science learning?

Theoretical Framework

The expected contribution of primary school science learning towards science literacy encompasses three points, namely *attitude development* (admiration, enthusiastic, and interested), *ideas development* (understanding important ideas and its explanation framework), and *process skill development* (science inquiry procedures) (Millar & Osborne, 1998; OECD, 2003; Harlen & Qualter, 2004). Piaget (1929) is a pioneer in learning children's development using a clinical interview approach. Many of the science education experts have adapted this clinical interview to learn children's ideas in depth in the context of science learning (Osborne & Freyburg, 1985; Posner & Gertzog, 1982). Science learning implemented by teachers may not necessarily effective in influencing children's conception of science without any convincing evidence. Moreover, the conception that has been formed a long time through learning experiences certainly requires an effort to turn it into a new conception that is more scientifically accountable by presenting more convincing evidence for children (Osborne dan Freyburg, 1985).

To help to raise and increasing skills in bringing up science ideas, there has been a lot of relevant learning strategies developed for science learning. Three of the strategies are (1) *learning cycle* strategy (Lawson, Abraham, & Renner, 1989), (2) analogy strategy (Stavy, 1991), and (3) the use of oral and written language strategy (Fellows, 1994). The three strategies have been implemented by many researchers to help teachers overcome science misconceptions. Besides, science literacy sees the importance of process skill and attitude development as well as the ability to link learning experience with the outside world (Harlen dan Qualter, 2004).

In line with the nature of science, the science education literature believes that teacher's and student's understanding of the nature of science (NOS) is a central point in its relation to science literacy (Mc. Donald, 2008). Teacher's understanding and beliefs about NOS form the part of "*the hidden curriculum*" which is highly influencing the way they teach. However, most science teachers have a mistaken understanding of it (Lunn, 2002). Remembering the facts and algorithms or procedures for solving a problem is a common picture seen in science learning

activities, Tobbin and McRobbie's study succeed in identifying the misunderstanding and misinterpretation of a middle school teacher in their science learning.

Teacher's view about NOS is also variously identified in the many teaching materials they use. (Harlen dan Holrod, 1997). The result of the study performed by Stein, Barman, and Larrabee (2007) shows that children's misconceptions about science are caused by the learning process implement by their teacher. Although teachers have a good understanding of NOS, the way they teach science can also result in misconceptions (McDonald, 2008). Scientists and science teachers in the United States agree that science is a way to explain the *natural world*. The most important part of science education according to *the Next Generation Science Standards* (NGSS) is science learning, practical science engineering, and development of science concept knowledge which is the basis of scientific knowledge. In the education environment, the learners have to develop an understanding of science as a while through admiration or interest, eagerness to investigate, inquire, conduct data or fact collection, also analyzing the obtained data or fact. To achieve those objective NGSS formulated the meaning of nature of science as follows: a scientific investigation using various methods; scientific knowledge is always based on empirical evidence; scientific knowledge is open for revision if a new stronger and more accurate evidence exists; scientific model, law, mechanism, and theory are explaining natural phenomenon; science is a way *of knowing*; scientific knowledge is assumed as an organized and consistent nature system; science is human's effort, and science always inquire about nature and world.

The implementation of various investigation method enables the student to be accustomed to seeing scientific phenomenon using a different point of view. A different way to seeing differently allows the growth of critical thinking power which in turn (with the facilitation of the teacher) can improve the conceptions that have been formed previously. The studies conducted by Posner, et al (1982) and Lin (2016) shows that the improvement of science conceptions can be encouraged by a different way of seeing, including the implementation of the various method. In those studies, the use of various ways of seeing can trigger cognitive conflict which facilitates the change of student's conception. Besides, learning does not stop as the conception is formed, but significantly the development of abstraction, generality, and metacognition ability.

Scientific knowledge is developed based on empirical evidence. The evidence is observed aiming to see whether there is a pattern or no from the obtained data. For this purpose, NGSS suggests the utilization of technology in the measurement process to generate more

accurate data. As proposed by AAAS (1993), science is partly based on real-world observation, thus gradually, the claim validity in science refers to observation results towards the natural phenomena observed. Nevertheless, Lederman, Abd-El-Chalik, Bell, and Schwartz (2002) states that scientists do not own direct access to most of the natural phenomena they observe. Therefore, instruments or equipment (technology) is used to help in conducting observation or measurement towards the natural phenomenon. As a result, in the context of science learning, accustoming students in making an inference based on empirical evidence gained from observation results (including a particular instrument) is a fundamental aspect of science learning.

Concerning the importance of empirical evidence in science learning Lederman, Lederman, and Antink (2013) highlights the meaning of observation and inference which should be the science teacher's main concern. Lederman et al views observation as a descriptive natural phenomenon that can be directly accessible by human senses such as throwing on top of the soil will fall on to the soil. While inference is a statement about natural phenomena that cannot be directly described tangible things, such as a statement that 'an object tends to fall on top of the soil surface is caused by gravitation'. This idea about gravitation is not simple because generating inference requires facts of observation results which portrays the cause-effect relation from the existence of attractive force between natural objects.

Nature is a system in which its components have linkage one to another. Consequently, many natural events can be predicted such as weather, eclipse, and time. Likewise, natural events causing many victims such as floods and landslides over time. Accordingly, knowing and learning nature as an orderly system is very crucial for humans so that they can benefit from each of these events and orders. For this reason, one of the studies contained like science is related to nature as a regular system so that natural laws understood by humans will be similar everywhere (Bybee, 1997; Khisfe & Abd-El Chalick, 2002; Lederman, 2007). One of the aspects contained like science is that human effort, including its learning. There are various ways to introduce it through education that has been widely studied (Lederman, 2007). Based on Lederman, many efforts have been made to develop aspects of the nature of science (NOS), but at the beginning, NOS was seen as an implicit part of science. Based on the analysis result of several previous studies, Lederman (2007) concludes that the result of NOS learning implicitly is not effective. A study conducted by Abd-El Halick & Lederman (2000) assumes that students will know the nature of science through science learning activity implicitly. This study explains that the more students involved in a science learning activity, the more likely

they are to know and understand the nature of science. Nevertheless, several studies conducted later, it is found the fact that explicit and reflective learning is given more prospects to the understanding of the nature of science (Khisfe & Abd-El Chalick, 2002; Scharmann, Smith, James, & Jensen, 2005).

The introduction of the nature of science (NOS) has been recommended through explicit and reflective learning through direct interaction with nature. It is stated in a research conducted by Liu & Lederman (2002) through *science camp* program held in Taiwan. Similarly, Mc Comas has conducted the program in 1998. The two studies convey the importance of an explicit approach to introduce the nature of science (NOS) through direct interaction with nature so that students have the opportunity to interpret the phenomena related to science concept understanding through a reflective thinking process over the problems contained therein, especially those related to everyday life. Abd-El Chalick (2012) emphasizes the further result of his study, that NOS can be introduced in two contexts as a way to understand nature (*teaching with NOS*) and learning the nature of science itself (*teaching about NOS*). This result of the study explains further that NOS as a way to understand nature has a role in providing students experiences through the science process directly so gradually formation of an understanding of the evidence-based science conception is obtained through the learning process. Hence, the epistemological aspect of scientific knowledge formation is ensured through a process of direct experience, and the constructed conclusion of the process is based on observational data. The nature of science (NOS) as a learning focus also has an important role, particularly in directing the learning process following NOS principles as stated previously.

Thus, teachers who always make efforts to innovate in each of their learning, tend to always develop their type of craft knowledge. Meanwhile based on the study result of Pajares (1992) found strong evidence that a person's beliefs that have been formed through a long process of experience will usually find it difficult to change in adulthood. This research indicates the importance of establishing a teacher belief system that was formed at a young age through a research civilizing process for teachers.

The practical knowledge as explained by van Driel, Beijaard, & Velloop (2001), is teacher knowledge formed based on the work experience as a teacher integrating experiential knowledge, formal knowledge, and *personal beliefs*. This explanation is almost similar to Feldman's (2000) statement about the meaning of practical theory, namely the occurrence of

conceptual changes that occur to the teacher based on his practical experience in conducting daily learning.

Personal pedagogical knowledge, according to Morine-Dersheimer and Kent (1999), is the result of interactions between personal practical experiences, belief systems, and perceptions. These are explained to distinguish it from the knowledge formed by formal learning experiences. Meanwhile, Shulman (1986) uses the term *Pedagogical Content Knowledge* (PCK) to describe the type of knowledge teachers have so that they can help the student learn the content knowledge well. According to Magnusson, Krajcik, and Borko (1999), PCK needed to create better science learning includes five components, namely: (1) orientation towards science learning, (2) knowledge and beliefs about science curriculum, (3) knowledge and beliefs about students' understanding of certain science topics, (4) knowledge and beliefs, and (5) knowledge and beliefs about science learning strategies.

METHOD

This qualitative research is related to the existence of science learning in the fifth grade of Gagas Ceria Primary School in Bandung. Ary, Jacobs, and Sorensen (2010), states that qualitative research cannot be separated from the context and meaning problems. In this research, the problem context which becomes the focus of the observation is learning that includes the characteristics of science teaching materials, teachers' views on science learning, science learning process, and principal's view on science learning and science learning. While the meaning that is the focus of attention is the extent to which the aspects observed are related to the basic principles of the nature of science. The data used include (1) learning design documents, teaching materials developed by teachers, (2) results of interviews with the teachers and school principal, (3) video of learning as the observation result and its transcripts. The data are analyzed through several stages including organizing and interpreting data, characterizing and reducing data, as well as the data presentation and interpretation. (Ary, Jacobs, dan Sorenses, 2010).

RESULTS AND DISCUSSION

Results

As stated by Harlen and Qualter (2004), the main purpose of science learning at schools is similar to science literacy. Harlen and Qualter (2004) define science literacy as a fundamental understanding of science that must be part of science education, which includes: (1) the ability to use scientific knowledge concerning scientific aspects about the surrounding environment,

(2) the ability to see things from the scientific point of view, and (3) have an awareness about the nature of science and the role of the scientific knowledge value for its generation.

The results showed that there were efforts made both by school principal through the development of policies about the learning quality improvement and by teachers who had direct or indirect relations with the purpose of science learning stated above. In terms of the school principal's policy, the efforts made to conduct *professional development* through various means including training and *lesson study*, are an indication of concerns for the quality of learning. On of the learning meanings conveyed by the principal, is how students able to master the knowledge and its application in overcoming everyday problems. It shows that science learning in this school is not only directed at the knowledge acquisition, but also on its interpretation for the students' life in creating, innovating, and contributing to the interest of the environment.

The principal encouragement to create more explorative learning so that students can learn to generate thinking or something creative, innovative, and contributive, implies that science learning has to be oriented towards the skill development which is beneficial for the nature empowerment so that it has benefit value for its generation. Based on the teacher's side, the efforts made to become a professional educator were shown by active involvement in some activities held by the school including attending training and lesson study. The engagement in the educator's community to make collaborative efforts in developing the quality of learning is also a prominent feature of the teachers' efforts in this school environment. The result of these activities is shown through the seriousness in preparing learning design, media and experimental tools used in learning, teaching materials in the form of a worksheet, and the learning process that tends to be more explorative. Teacher's encouragement in building knowledge and skills of the scientific process through developed learning is shown through exploratory attempt through experiments, utilizing students' experience and knowledge actively by asking questions, as well as efforts to encourage students to be actively involved throughout the learning process. In every observed science learning process, the teacher always encourages students to associate what is being learned with the surrounding environment known to the student. The urge to submit their conclusions in learning shows that the teacher is trying to help children see the phenomena faced from a scientific point of view. Besides, according to the context studied, many teachers also encourage students to build their awareness related to nature in terms of the nature of science aspects so that it can be beneficial for themselves and the surrounding environment.

Based on the result of the research previously presented, seven aspects of the nature of science were identified in observed learning, namely: (1) scientific investigation using varied methods, (2) scientific knowledge based on empirical evidence, (3) scientific knowledge is open for revision, (4) science is a way to understand nature, (5) science begins with the assumption that nature is patterned and orderly, (6) science is human effort, and (7) science talks about nature and the world. Although the first aspect, scientific investigation uses varied methods has not been prominently used, the efforts in that direction have begun to be seen, namely in the experiments using several different substances to see the effects on fish life. The way of seeing in various ways is important because it can encourage students to be accustomed to seeing scientific phenomena by using a different perspective. Using a different point of view can be useful in refining the conception or sharpening the way of seeing a problem. The existence of a different point of view allows the student to use critical and creative thinking skills, so their new understanding, knowledge or conception can always be constructed. This is closely related to the development of student's conception development about science. Posner, et al. (1982) and Lin studies (2016) show that the improvement of science conception can be driven by the use of different perspectives, including the use of varied methods. In both studies, the use of varied ways of seeing can trigger a cognitive conflict that can facilitate changes in students' conception. Besides, learning does not only stop at the formation of conceptions, but more importantly is the development of abstraction, generalization, and metacognition.

The next identified aspect of the nature of science is that scientific knowledge is open for revision. As previously stated, scientific knowledge is subjective (depending on one's theoretical perspective) (Lederman, 1999; Lederman, Lederman, and Antink, 2013). Because of its subjective nature, the process of developing scientific knowledge is highly influenced by theoretical views that are believed, experience, prior knowledge, as well as expectation towards natural phenomena being observed. In the context of science learning, both teacher's and students' good background knowledge has a very important role in interpreting a phenomenon being faced. Thus, not only improving their knowledge continuously, but teachers also have to find out the extent to which students' knowledge and experience are related to the phenomenon being studied. From some of the learning being observed, the findings revealed that students are more easily convinced by using observational data, especially direct observation. Empirical evidence used to develop children's scientific knowledge can be continually improved by presenting other evidence of new convincing evidence. Thus, the efforts to obtain better

evidence by looking better, measuring better, and explaining better are crucial to interpret the view that scientific knowledge is open for revision or improvement. From one of the studies observed, the fact that too many aspects were carried out caused children to become less focused so that the experiment process become less accurate. For this reason, the experiment process should consider more on observation quality aspects which can generate better empirical evidence. Through caution and accuracy in conducting experiments, students are expected to be more focused on producing data so that the subsequent inference performed further will produce better knowledge for the students.

Discussion

As stated in the results of this study, the object of study that is the subject of discussion in every science learning, especially those observed in this study, is related to humans and the surrounding environment. Teachers' efforts in presenting natural phenomena, making observations of these phenomena, collecting data as needed, analyze data, and submitting conclusions from the results of the analysis are essentially how humans understand nature. The limited ability to carry out scientific processes in children can be facilitated by the strategy of asking both exploratory and directing questions. Although the children in the findings of this study still seem to have difficulty in carrying out scientific procedures or processes, however, the strategy can be integrated to focus the child's thinking

Based on life experience and observations of its symptoms, nature is constantly changing, such as the weather cycle, the quality of the environment, water, forests, and many that change. As a result, science has a very important role in understanding various natural phenomena. The efforts to generate new knowledge related to the dynamics of natural change are very important in learning science. Some examples of studies indicating the importance of this include the one conducted by Arkerson and Donnelly (2010) about the importance of learning the nature of science in schools starting from kindergarten; Akerson and Hanuscin (2007) about the importance of inquiry in science learning; and Akerson and Volrich (2006) about the importance of learning the nature of science explicitly for prospective teachers. New knowledge gained based on science learning is expected to improve one's attitude in interpreting natural phenomena, because science is essentially a way to understand nature and its changes. Some of the lessons observed in this study indicate that many life problems are closely related to natural events such as floods, landslides, drought, and food difficulties. Those are closely related to human's efforts in finding solutions to the problems faced. The scientific approach to understanding nature and its effects as a result of humans behavior is very

important in science learning. It shows that science is essentially an attempt by a human to understand nature and use the knowledge to empower nature positively.

CONCLUSION

Based on the results and discussion of the research presented in the previous chapter, the following conclusions can be made. Judging from the main objectives of science learning, especially in elementary school, can be concluded that within certain limits, the initial student ideas about science that are triggered in the context of the problem of teacher creation learning, can be explored well demonstrated through answers to questions raised by the teacher and conclusions or student's statement on the problem being studied. The scientific phenomena displayed by the teacher accompanied by the strategy of asking are directing and exploring, which can help children's learning processes interpret the concepts and processes of science well. Science process skills and values developed through learning are also identified as developing well in context-rich problems (students are very well acquainted with the context of the problem being raised). The meaning of science learning is more fully illustrated when students are invited to try to relate it to the problems of everyday life.

Although the observed cases of science learning indicate seven aspects of the nature of science identified in the study being observed, the depth and integrity of the nature of science still need to be further developed. The aspects of the nature of science do not stand alone but are interrelated with one another. For example, the view that scientific investigations use varied methods has to do with other aspects such as the importance of empirical evidence in building scientific knowledge and empirical evidence resulting from the way data is collected, creating space for new arguments that impact on improving children's conceptions of science. The consistency between the teacher's view of the nature of science and its learning and the real practice of learning developed by the teacher is the ideal thing that is the aim of the teacher's professional development. In this case, the results of the study conclude that more progressive efforts are needed regarding scientific knowledge for the sake of learning towards teachers' beliefs about science and learning. The quality of learning science from the perspective of the nature of science is certainly very closely related to the teacher's belief system about science and learning.

Based on the results of this study, several implications can be put forward as follows. Improving the quality of learning science in the perspective of the nature of science requires the presence of teaching materials with a rich context; carrying capacity of a management

system that is substantial, touches on the issue of learning directly including increasing the professionalism of the teacher; and efforts to change the mindset or views of teachers about science and learning continuously. The implications of further research can be focused on efforts to improve the learning of science both concerning the management system in managing academic policy, and increasing understanding of the nature of science through reflective efforts undertaken collaboratively in the teacher community.

The results of this study recommend the following. First, there is a need for institutional efforts from schools to focus on increasing teachers' understanding of the nature of science and learning. Second, reflective studies on learning that have become a tradition in the school environment, in addition to continuing, also need to be improved, especially for science learning, by presenting the issue of the nature of science explicitly.

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