PERIÓDICO TCHÊ QUÍMICA
ARTIGO ORIGINAL

A EFICÁCIA DO MODELO DE APRENDIZAGEM EM LABORATÓRIO BASEADO EM ETNOSOCIOECOLOGIA PARA APLICAR A ALFABETIZAÇÃO AMBIENTAL EM PROFESSORES DE BIOLOGIA EM TREINAMENTO

THE EFFECTIVENESS OF INQUIRY LABORATORY-BASED ETHNOSOCIOECOLOGY LEARNING MODEL TO EMPOWER ENVIRONMENTAL LITERACY IN PRESERVICE BIOLOGY TEACHERS

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RESUMO

O ponto principal da alfabetização ambiental é aumentar a preocupação individual com a crise ambiental em ações concretas ou movimentos de cuidado ambiental. Esta pesquisa visa capacitar o conhecimento de professores de biologia da preservação sobre o meio ambiente e seus problemas em contextos ecológicos e sociais e habilidades cognitivas para investigar e planejar soluções para os problemas. O método de pesquisa quantitativa com o design de um grupo pré-teste e pós-teste foi empregado para testar o aumento do conhecimento ambiental após o aprendizado. O efeito estimulante são as habilidades cognitivas para superar problemas ambientais. Os participantes da pesquisa consistiram em 29 professores de biologia em treinamento cursando ciências ambientais no primeiro semestre. O conhecimento ambiental foi medido por meio de um teste de ensaio, enquanto a mensuração das habilidades cognitivas foi realizada por meio de uma rubrica com escala de classificação baseada nos resultados de investigações de problemas ambientais em campo. Verificou-se que o modelo de aprendizagem de etnossocioecologia em laboratório poderia melhorar significativamente o conhecimento ambiental. Além disso, o conhecimento ambiental está positivamente correlacionado com as habilidades cognitivas. Em geral, as habilidades cognitivas aumentam com maior conhecimento ambiental.

Palavras-chave: *habilidades cognitivas, conhecimento ambiental, alfabetização ambiental, etnossocioecologia, laboratório de investigação.*

ABSTRACT

The main point of environmental literacy is to increase individual concern towards the ecological crisis in concrete action or environmental care movement. This research aims to empower the knowledge of preservice biology teachers about the environment and its problems in environmental, and social contexts and cognitive skills to investigate and plan solutions to the issues. The quantitative research method with the one-group pretest-posttest design was employed to test the increase of environmental knowledge after learning. The nurturant effect is cognitive skills in overcoming environmental problems. The research participants consisted of 29 preservice biology teachers taking the environmental science course in the first semester. Environmental knowledge was measured using an essay test, while the measurement of cognitive skills was performed using a rubric with a rating scale based on the results of investigations of environmental problems in the field. It was found that the inquiry laboratory-based ethnosocioecology learning model could significantly improve environmental knowledge. In addition, environmental knowledge is positively correlated with cognitive skills. In general, cognitive skills increase with higher environmental knowledge.

Keywords: *cognitive skills, environmental knowledge, environmental literacy, ethnosocioecology, inquiry laboratory*.

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1. INTRODUCTION:

Developing countries characterized by high population growth and economic instability encounter various environmental problems. These problems include pollution, deforestation, the decline in natural resources, climate change, and extinction. Declining environmental quality is a result of economic instability. The exploitation of natural resources to increase economic growth is not followed by efforts to rejuvenate the environment (Begon, Harper, & Townsend, 2006; Hanif & Gago-de-Santos, 2017). Indonesia is one of the developing countries with the fourth highest population in the world with Java as the most populous island. Pressure on clean water supply becomes one of the environmental problems found in densely populated areas. The clean water crisis is the impact of the conversion of green land into agricultural land, residential areas, mining, and industry. Flood is no longer a natural phenomenon, but a result of poor land management and spatial planning (Asian Development Bank, 2016).

Considering such conditions, concern for the environment should not only be a tendency towards attitude, but also be manifested in concrete actions (Mishra, Akman, & Mishra, 2014), one of which is to empower students in increasing their knowledge of the environment and applying it to overcome problems that are happening around them (Bodzin, 2016). Environmental education as an agent for formal learning is very effective for students to participate in sustainable development that prioritizes the environmental care aspect (Hoang & Kato, 2016; Varela-Candamio, Novo-Corti, & García-Álvarez, 2018).

One theme in 21st-century learning is environmental literacy (Pacific Policy Research Center, 2010) as a response to changes in environmental and socio-economic conditions. These changes stem from pressures due to population growth, urbanization, economic development, increasing inequality, and poverty rate (Delgado-Serrano, Mistry, Matzdorf, & Leclerc, 2017). Environmental literacy can be built through environmental education to gain in-depth knowledge, skills development, and authentic experience about environmental changes around students. More than that, students are expected to become part of a community that actively responds to the environmental crisis through concrete efforts (Coyle, 2005). Environmental education must use a multidisciplinary learning approach in order to produce a broad knowledge of environmental science and skills to overcome environmental problems. Thus, environmental literacy is the highest goal of environmental education (Bodzin, Klein, & Weaver, 2010).

21st-century learning emphasizes mastery of higher-order thinking skills (HOTS) and complex cognitive processes (Greiff, Niepel, & Wüstenberg, 2015; Partnership for 21st Century Skills, 2009). These skills are supported by critical-thinking, problem-solving, communication, and collaboration so that individuals can adapt to various challenges in the globalization era (Saavedra & Opfer, 2012). Critical thinking and problem-solving are part of cognitive skills. Meanwhile, communication, collaboration, and social responsibility belong to interpersonal skills (Koenig, 2011). Creativity as a component of problem-solving skills is obtained when a person develops their thinking from various perspectives and is applied to new conditions (Partnership for 21st Century Skills, 2012).

21st-century learning is preferred to integrate approaches based on technology, inventions, problems, and HOTS (Partnership for 21st Century Skills, 2009). Growing technology facilitates students to work both independently and in groups. Technology helps in collecting relevant information, analyzing the relationship between information, constructing new knowledge, and presenting that information clearly from all aspects studied (OECD, 2008). In addition, technology is also used in the assessment of learning (Nikou & Economides, 2017). Students must be accustomed to finding answers to a problem by collecting and assessing the accuracy of the information, organizing information, and concluding (Griffin, McGaw, & Care, 2012; NAAEE, 2015).

Teachers at every level of education must possess in-depth knowledge and relevant experience relating to the environment, both the concept and the problem, before teaching the students (Nagra, 2010). This ability is significantly influenced by experiential learning such as learning that utilizes the natural environment, examines environmental problems, plays an active role in environmental management activities (environmental activists), and teaching practices on environmental education (Torkar, 2014). The important aspects to be considered in environmental education include learning relevant to everyday life, involving various parties such as society, family and role models, allowing students to interact with the social environment, direct experience, freedom to determine learning topics, studying local problems, and encouraging community movements (Wilson, 2011). Given the importance of environmental education to improve environmental literacy in students, program or curriculum evaluations need to be carried out correctly to determine the progress, difficulties and the level of goal achievement (Spinola, 2015).

Therefore, the study aimed to empower the environmental knowledge and cognitive skills as the variables of the environmental literacy of preservice biology teachers.

2. LITERATURE REVIEW:

There are various definitions of environmental literacy and elements that make it up. According to NAAEE (2004), environmental literacy has four main components: (1) curiosity about the condition of the surrounding environment followed up by finding information, testing the truth and building a knowledge; (2) a deep understanding of human interaction with the environment; (3) measures to assess environmental problems and find solutions; and (4) awareness that each individual has a role to better change the environment. The first component consists of special skills, namely asking questions, designing investigations, gathering information, evaluating the truth of information, organizing information, reviewing and conducting simulations, and concluding and delivering explanations. The second component includes an understanding of the earth system, the concept of the environment, humans, and their culture and human interaction with the environment. The third component refers to the skills of analyzing and investigating environmental issues and making decisions. The fourth component includes understanding social values and principles, recognizing the rights and responsibilities as citizens, being confident and responsible for the actions taken (NAAEE, 2015).

According to Hollweg et al. (2011), the component of environmental literacy consists of knowledge, attitudes, competencies, and environmentally-responsible/friendly behaviors. Knowledge includes systems in physics and ecology and environmental issues. Attitude refers to sensitivity, environmental care, the motivation and purpose of taking action to deal with environmental issues. Competence emphasizes the skills and abilities to identify, analyze, create solutions, and evaluate actions to address environmental problems. Environmentally-responsible behavior is manifested in the form of individual or group involvement to overcome problems and prevent the emergence of new conflicts such as environmental management activities, campaigning for environmental care, and using environmentally-friendly products.

The learning of environmental science is multidisciplinary (Miller & Spoolman, 2010). Students need to learn concepts related to ecology, economics, social, politics, and culture (NAAEE, 2015). The integration of diverse knowledge and scientific disciplines helps students analyze a problem from various perspectives. Not only do students need to master the concepts related to systems and processes that occur in the ecosystem, but they must also critically analyze how economic development, social and cultural changes, and environmental management policies can impact the environment (Kusmawan, O'Toole, Reynolds, & Bourke, 2009). Students need to be accustomed to exploring existing problems in the surrounding environment to grow their concern and awareness of the decline in environmental quality due to human interaction with the environment (Zareie & Navimipour, 2016).

The pilot study shows that the preservice biology teacher in the second semester still has a low or inadequate level of environmental knowledge. There is 63% of a preservice biology teacher who gets a score of less than six from 10 questions. Besides that, there is an inconsistency response, especially about the limitation of private land use and environmental protection of wildlife. Furthermore, the practice of environmental education needs to be improved to grow ecological literacy through the understanding of the environment and its problem and real action to respond to the environmental changes surroundings.

Developing environmental knowledge means increasing environmentally-friendly behavior as it reflects the level of one's environmental knowledge (Zareie & Navimipour, 2016). Educational institutions and the government can collaborate to increase students' knowledge about the environment that refers to the ecological and social context. Through formal efforts, the government mediates the community with academics to collaborate, share information, and conduct research. Thus, various parties contribute to achieving a balance between social and ecological aspects and sustainable development goals. Information and research results are then used as learning content for the development of environmental knowledge, stimuli of changes in environmentally-friendly behaviors, and empowering skills to cope with changing environmental conditions (Krasny, Lundholm, &

Plummer, 2010).

Individuals who care about the environment not only have a deep understanding of environmental problems and issues but also master cognitive skills in addressing environmental problems (Hollweg et al., 2011). Cognitive skills involve students to use their prior knowledge to solve new problems and build new knowledge. Students need to actively explore a problem, apply the knowledge they have learned leading to the discovery of ideas or new problem-solving strategies. Cognitive skills involve the ability to think critically to specify the problem and connect a variety of information and the ability to think creatively to find effective and innovative solutions (Koenig, 2011).

One's action on the environment from the Theory of Reasoned Action perspective is influenced or determined by several factors. The fundamental factors in determining a person's behavior include personal, social, and knowledge background factors. These factors affect one's belief in behaviors and norms that exist in society. A person's trust determines his/her attitude towards a behavior and norm and behavior control. Attitudes, norms, and behavioral control further determine or influence the purpose of an action. Through learning environmental science, students are expected to utilize their prior knowledge of the environment to be transferred into positive attitudes and behaviors towards the environment (Fishbein & Ajzen, 2010).

Applying knowledge to do a set of cognitive skills in problem-solving is an example of experiential learning. Inquiry learning is one example of experiential learning that helps students connect theory with practice. Prior environmental knowledge is enriched through the activities of investigating environmental problems in the field. The prior knowledge and knowledge gained during the investigation are interrelated to test the truth of the previous knowledge. New knowledge that is built through the process of finding information, observing, measuring, and analyzing is utilized as a new stimulus to make decisions in similar new situations. Also, the inquiry method in environmental science learning trains students to reason according to the evidence obtained during the activities of problem identification, gathering facts of the problem, planning problem-solving actions, predictions, making relevant decisions, and linking problems with the specified solutions (Dewey, 1938).

Inquiry laboratory learning is also one example of the application of meaningful learning theory. Students build new knowledge by organizing the entire prior knowledge with the information being studied (Savin-Baden & Major, 2004). The previously-owned knowledge is adjusted to new conditions or problems in order to produce creative ideas, for example in overcoming the problem of pollution or waste (King, Keohane, & Verba, 1995). Students not only get concepts available in the form of textbooks but also learn to explore information in the field, analyze, organize, and make conclusions about environmental problems and the solutions (Ausubel, 2000).

Environmental science is interdisciplinary. Various disciplines are interconnected, for example in handling fisheries problems. To address these problems, they need to be studied from the aspects of environmental economics, political science, ecology, chemistry, anthropology, and population biology. Explaining the environmental problems at the beginning of the learning is expected to stimulate students' ability to reason from various perspectives and to recall the knowledge or experience they have. Different opinions of the students with heterogeneous academic and communication skills help them in the transfer of knowledge, enriching insight, and cognitive development in social interaction (Vygotsky, 1978). Environmental science learning in study groups encourages students to exchange opinions, consider the advantages and disadvantages of planned solutions, and make decisions based on mutual agreement (Swartz & McGuinness, 2014).

According to the socioecological theory of systems, there is a close relationship between social systems and ecology. Besides living and forming community groups, humans also depend on nature to get ecosystem services (Patten, 2016). This system aims to safeguard and enhance ecological resilience in supporting human survival by continuing to prioritize ecological principles in adaptive ecological management (Mathevet, Thompson, & Folke, 2016). This system is useful for the identification of causal relations between components in ecology and social to produce a mechanism to adapt to changes that occur in both systems (Kappeler, 1999). Local knowledge is one form of adaptive ecological management (Pauli, Abbott, Negrete-Yankelevich, & Andres, 2016).

Knowledge about the environment consists of scientific knowledge and local knowledge. The combination of both kinds of knowledge contributes to reducing the possibility of environmental damage as a result of the use of the environment (Mercer, Dominey-Howes, Kelman, &

Lloyd, 2007; Thornton & Scheer, 2012). Traditional ecological knowledge is obtained from the habit of people interacting with nature directly, including knowledge about living things and natural phenomena, as well as how to manage the environment such as farming, raising livestock, and hunting (Inglis, 1993). Local knowledge arises and develops among the people who have lived in an area for a long period and retained it because it provides benefits for their life and environment. Although local knowledge is not obtained through scientific testing, the truth of the knowledge can be scientifically proven through integrated science learning (Parmin, Sajidan, Ashadi, Sutikno, & Fibriana, 2017).

The use of local knowledge in environmental education can enrich the knowledge of preservice biology teachers related to sustainable environmental management practices. Students are encouraged to participate in overcoming global problems by utilizing local knowledge in their surroundings (Palmer, 2003). Ethnoecology is also called local knowledge, traditional knowledge, or traditional environmental knowledge, which is often used interchangeably. Ethnosocioecology is a set of knowledge and perceptions of local people in environmental management practices to adapt to changes in ecological and social systems.

Integrating local knowledge about the environment in learning has several advantages: (1) it completes and provides reinforcement about science that can generate new thinking and develop problem-solving skills (Evering, 2012); (2) it raises awareness about local knowledge; (3) it facilitates students to develop critical-thinking skills; (4) it fosters cooperation with local communities to create sustainable communities (Dei, 2000).; (5) it strengthens the character education of students (Adilah & Saputra, 2013; Marhayani, 2016); (6) it improves problem-solving skills, scientific investigations and environmental care attitudes (Dewi, Poedjiastoeti, & Prahani, 2017); and (7) it helps students apply and transfer their knowledge to everyday life (Gitari, 2010).

The inquiry laboratory is the fourth level of inquiry after discovery learning, interactive demonstration, and inquiry lessons. Inquiry laboratory has a characteristic that is to demand the independence of students in exploring their knowledge and the locus of control is entirely on students. Students are given the freedom to determine the problems and procedures used in inquiry and problem-solving. Lecturers act as facilitators who provide opportunities for students to conduct investigations and provide support or assistance only when needed because college students are adult learners who already have the psychological ability to study independently (Flick & Lederman, 2006). The main objective of laboratory inquiry-based learning is to formulate empirical laws based on measurements of variables. The process skills needed in this research include measurement, formulation of empirical laws based on evidence and logic, designing scientific investigations using technology, and calculating (Wenning, 2005; 2010; Wenning, Khan, & Khan, 2011). However, not all students have the same level of process skills in testing or collecting data. Therefore, in this research, students are provided with guiding questions or points that need to be studied as guidance in conducting investigations. Meanwhile, problem-solving planning is entirely determined by students according to their level of critical thinking and creativity.

The inquiry laboratory-based ethnosocioecology learning model consists of observation, manipulation, investigation, generalization, verification, and application stages. The observation stage is the identification of problems in the classroom from the guiding questions raised by students under the topic or theme of learning. Based on the identified problems, students determine one main problem and design a problem investigation procedure (related to the environment) independently at the manipulation stage. The draft includes determining the location of the investigation, compiling a list of questions to gather information directly from the local community related to the topic of the problem, and planning or predicting problem-solving actions. The next stage is the investigation. Students carry out investigation activities in the field according to plan. After obtaining information through interviews and observations, students analyze the problem including the causes and effects supported by the study of relevant theories and determine solutions relevant to the problem. In the generalization stage, students formulate conclusions based on the data analysis. The problems investigated and analyzed are presented in discussions to get various information and responses from other students. This stage is called the verification stage. The application stage is the implementation of the conclusions from the results of the discussion as reinforcement and confirmation of the truth about students' prior knowledge related to environmental problems to solve problems in new situations or answer questions (Figure 1).

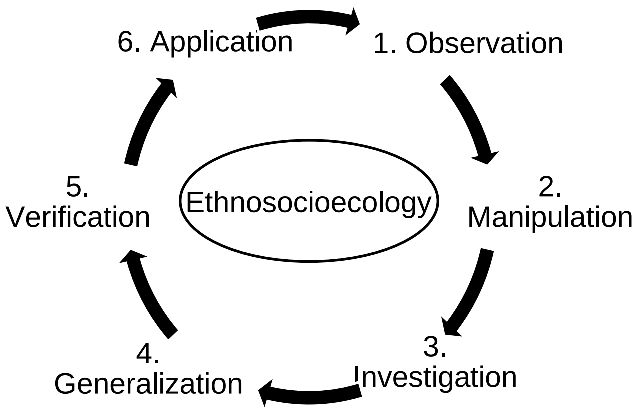

Figure 1. *The model of inquiry laboratory-based ethnosocioecology*

In addition to the independence that takes precedence in inquiry laboratory learning, the use of local knowledge content is the basis for students in conducting the stages of inquiry laboratory. Before students determine the environmental problems to be studied, they explore prior knowledge related to local knowledge on the use or management of the environment, components contained in local knowledge (knowledge, practice, and beliefs), how local knowledge arises and is transmitted over generations, and the benefits of applying local knowledge to environmental sustainability. Apart from being used to increase students' knowledge about the environment, local knowledge is also used as a basis for students to develop ideas for solving environmental problems that are further investigated. Thus, students indirectly prove the truth of local knowledge related to its role in environmental preservation.

3. MATERIALS AND METHODS:

To test the effect of inquiry laboratory-based ethnosocioecology learning model on the empowerment of environmental literacy, one-group pretest-posttest design was used. Before conduct the study, the researcher submits the research permit that known by the supervisor and approved by the faculty to the head of the biology education study program. The document was forwarded to the practitioner and discuss the form of collaboration between practitioners, students, and researchers along with the study. The sample consisted of 29 preservice biology teachers. As the environmental literacy construct that has been previously defined, which is a set of knowledge about the environment and its problems in ecological and social contexts and cognitive skills in problem-solving, the environmental literacy in this research consists of two variables that are environmental knowledge (EK) and cognitive skills (CS). This research was conducted in 5 cycles (two meetings of each cycle). In each meeting, there were 29 preservice biology teachers, a practitioner/lecturer, and three observers.

Each meeting lasts for 100 minutes in the classroom. As shown in Figure 1, the syntax of inquiry laboratory-based ethnosocioecology consists of six syntaxes. In each cycle, students investigate one topic of environmental problems and design a solution. The activity of the first meeting in each cycle is observation and manipulation. Environmental problems and local knowledge that have been identified in the classroom are followed up with investigation in the field. Preservice biology teachers do the investigation and generalization syntaxes in the field. The specific problem was investigated and analyzed deeply and designed the solution. The result of field investigation was presented in a paper which consists of problem identification, problem investigation, problem analysis, and solution. Practitioners and biology preservice teachers communicate within a WhatsApp group during field investigation. Students and the lecturer could discuss the difficulties and share the information at the field in the form of pictures or videos, and the lecturer and observer could control the student progress and activity. The second meeting of each cycle is for verification and application syntax. The student reports the field investigation and solution then discuss it with other groups. The observer records the activity of learning such as how the implementation of each syntax, what difficulties, and learning progress.

The materials used in the learning module include (1) introduction to environmental science and ethnosocioecology, (2) environmental principles and ecosystem management models, (3) ethnosocioecology as an example of the application of environmental ethics, (4) components and processes in the ecosphere, and (5) ecosphere problems and the resolution efforts. Investigation topics related to these materials include (1) the problem of green land conversion, (2) environmental management and problems, (3) examples of local knowledge as a form of environmental ethics, (4) carbon cycle disruption, and (5) local environmental problems. These topics encourage students to dig deeper information from various viewpoints, experiences, and public knowledge, and observe environmental conditions directly. Students analyze the data collected with relevant theoretical studies. Based on the facts and study of the theory, students find reinforcement and confirmation of the truth related to environmental issues that have been the subject of the global discussion. Investigation of local knowledge in the community enables students to think locally and act globally or encourages them to solve global problems by utilizing the local potential around them.

Preservice teachers were given a pretest before learning and posttest after completing learning in each cycle. Pretest and posttest were used to measure students' environmental knowledge. Pretest and posttest were given in the form of description questions that had been tested for validity and reliability. In addition to providing tests, the researcher also assessed students' cognitive skills in solving environmental problems. Cognitive skills were assessed using a rubric with a rating scale. There are 4 indicators of cognitive skills, namely problem identification, problem investigation, problem analysis, and problem-solving. These indicators were assessed through the paper resulted from field investigation. Each indicator was assessed by four rating scales 1= unclear and irrelevant, 2 = slightly unclear and irrelevant with the problem, 3 = clear but slightly relevant to the problem, 4 = clear and relevant to the problem.

T-test was used to determine differences before and after learning inquiry laboratory-based ethnosocioecology on environmental knowledge. Before conducting the test, the data were tested for normality and homogeneity as prerequisites. To find out whether there is a positive correlation between environmental knowledge and cognitive skills, Pearson's correlation test is performed. Before the data correlation test, the data linearity and normality were tested.

4. RESULTS AND DISCUSSION:

Based on the results of the normality test using the Kolmogorov-Smirnov test, the pretest and posttest data in the five cycles showed normal distribution of data ($p > 0.05$) and based on the homogeneity test using Levene test, the data were homogeneous ($p > 0.05$) (Tables 1 and 2).

The cognitive-skill data in the five cycles also showed normal distribution and had homogeneous variants as well as significant values of more than 0.05 (see Table 3 and 4).

After the prerequisite tests were fulfilled, the data were analyzed using paired t-test to find out whether there are significant differences before and after the application of inquiry laboratory-based ethnosocioecology on students' environmental knowledge. The data from the five cycles were used in the paired t-test. The analysis showed that there was a significant difference between before and after the treatment ($p < 0.05$) (see Table 5). Thus, the inquiry laboratory-based ethnosocioecology learning model is effective in empowering environmental literacy.

Cognitive skills were measured using an assessment rubric based on the results of investigations of environmental problems and the resolution efforts. The linearity test results from the five cycles showed that the value of deviation from linearity is more than 0.05. This means that environmental knowledge and cognitive skills have a linear relationship. After the prerequisite tests were met, the data were tested using the Pearson correlation. The Pearson correlation test results show a positive correlation coefficient close to 1 with a significance value of less than 0.05 (see Table 6).

This means that environmental knowledge and cognitive skills are positively correlated. In general, higher environmental knowledge will be followed by an increase in cognitive skills. Based on the results of the t-test, it was found that the inquiry laboratory-based ethnosocioecology learning model is effective in increasing environmental knowledge. Higher environmental knowledge will lead to an increase in cognitive skills in solving problems.

In cycle 1, the experimental-class students investigate problems related to the conversion of land use for the batik industry, tourism, shops, housing, and infrastructure. In cycle 2, students study problems regarding environmental management for animal husbandry, tourism, agriculture, and household waste treatment plants. In cycle 3, students investigate examples of local community knowledge in farming, namely the use of straw in growing rice seedlings, crop rotation, polyculture planting systems on private land, and terracing systems. In cycle 4, students conduct interactive simulation activities on carbon cycle disruption and food webs and create a design to overcome these problems. In cycle 5, students study environmental problems that have long been experienced by residents, namely water pollution and waste problems. Students analyze and communicate the results of investigations and design solutions obtained at the second meeting in each cycle.

Various solutions are produced after students analyze the problem. In cycle 1, one of the solutions designed is the use of natural materials from plants such as leaves, flowers, stems or roots, and others as natural batik dyes. The natural batik dyes can reduce water pollution due to the batik industry with harmful chemical dyes. In connection with the problem of environmental management for cattle farming, namely livestock manure, in cycle 2, students plan a strategy in the form of using animal dung to be made composted and to be made biogas. In cycle 3, relating to examples of local knowledge, students prove the use of straw in increasing soil fertility and moisture applied in the practice of growing rice seeds. Also, students examine the effect of crop rotation and polyculture systems on soil fertility.

In cycle 4, students simulate the carbon cycle for carbon cycle disturbance material. Interactive simulations, instead of investigations in the field, involve students actively in changing certain parameters and observing changes that occur. The data collected are then analyzed to build new knowledge. Through these simulations, students can understand the process of the ongoing carbon cycle, carbon distribution in the ecosphere, and the influence of increased use of fossil fuels and carbon levels on the survival of life on land and water. After analyzing the problem, students create the design of the solution to overcome the carbon cycle problems while still referring to local environmental management practices.

In the simulation of food webs, students practice making predictions of the increase or decrease in the number of producer and consumer populations in an ecosystem. Then, they prove their predictions through simulations and make modifications to the food webs so that each trophic can maintain their survival in the ecosystem. The results of the investigation through simulations are generalized and verified in class discussions. Communicating the results of the simulation also becomes a medium for students to compare the results of their investigations with other study groups.

In cycle 5, they examine the ecosphere problem and its solution. Students study water and garbage pollution problems. Through the activities of problem identification, problem investigation in the field, literature studies, and problem analyses, students can create a water pollution problem-solving plan by utilizing natural materials namely Moringa plant seeds from the surrounding environment combined with a simple screening tool. For the garbage problem, students design solutions by replacing plastic bags with cloth bags that can be used repeatedly, using plastic waste as chairs or tables made up of eco-bricks, and processing cardboard waste into reusable items such as makeup equipment, mini cabinets, tissue holder, and stationery.

Based on the test results in cycles 1 to 5, there is an increase in the average posttest scores in the experimental class. This shows that the ability of students to analyze and evaluate problems related to environmental management is increasing in each cycle. Besides, there is an increase in the students' ability to solve environmental problems with information obtained during the study group's investigation and discussion. After the paired t-test, it was found that there is a significant difference between the means of the posttest and pretest of environmental knowledge in the experimental class.

Based on the results of the Pearson correlation test, it is known that there is a significant positive correlation between environmental knowledge and cognitive skills. This shows that the high value of environmental knowledge, in general, is followed by the high value of cognitive skills. Thus, the inquiry laboratory-based ethnosocioecology learning model is effective in empowering environmental literacy for the aspects of environmental knowledge and cognitive skills.

Learning activities that examine the problem of land-use conversion, environmental management problems, environmentally-friendly management practices, simulation of material cycle disturbances, and environmental problem resolution help students develop their environmental knowledge (Partanen-Hertell, et al., 1999). Students practice connecting the causes and effects of environmental problems from observation and investigation activities (Erdogan, 2015). Multidisciplinary environmental science encourages students to evaluate the relationship between ecological and social aspects that contribute to the emergence of environmental problems (Steg & Vlek, 2009). Understanding these relationships becomes the basis to apply their knowledge critically in the face of environmental changes that occur (Sorensen et al., 2015). Student-centered learning activities reinforce environmental care (Bissinger & Bogner, 2017).

Studying local knowledge applied by the community such as crop rotation, intercropping system, and using straw in the farming system can foster students' awareness that the practices carried out by local communities need to be preserved. Insights into the benefits of local knowledge encourage students to develop ideas for solving environmental problems that are environmentally friendly that do not lead to new problems and reduce the environmental damage caused by the existing technological development (Kimmerer, 2012). Learning through direct experience in the field contributes to building knowledge about the environment (Brenner, Hamilton, Drake, & Jordan, 2013; Stevenson et al., 2014).

Students' cognitive skills improve from cycle 1 to 5. The stimuli given in the form of environmental issues encourages students to have group discussions (Savin-Baden & Major, 2004). Students are trained to convey their knowledge, experience, and ideas related to issues that are of concern around them. Investigating environmental problems helps students connect their prior knowledge with information being learned to build new knowledge. Contextual learning contributes to linking theory with practice (Agung, 2015; Reyes-García et al., 2010).

Studying environmental science is not enough to master the concepts of the environment, but it is very important to deepen understanding of environmental issues or problems. An understanding of the environmental conditions around them is expected to lead students to take action. Investigation of environmental problems in the field begins with identifying the problem. Problem identification helps students determine specific problems to be studied further by gathering information in the field. The data obtained are then analyzed to deepen understanding of the cause and effect relationship. The analysis of the problem is then followed up by finding relevant and applicable solutions (Bodzin, Klein, & Weaver, 2010).

The lecturer acts as a facilitator when the students plan and carry out investigation activities. The lecturer actively accommodates students' ideas in preparing investigation plans. When students find it difficult to determine the specific topic to be studied, the lecturer provides an example of his previous experience so that students have a picture and can make decisions. Also, the lecturer provides an immediate response whenever the student needs opinions related to the topic to be further investigated. The lecturer encourages the freedom and independence of students in designing investigation activities while still providing space for discussion. The facilitation used is in the cooperative form (Heron, 1989; 1993).

During the observation and manipulation activities, verbal strategies are applied by the facilitator. The first strategy is giving questions to train students to express ideas or prior understanding of the issue being discussed. The second is providing support and trust that students can convey their prior knowledge. The third is providing conclusions on the ideas or answers given. The fourth is giving back the questions of the students to be answered or responded by others. It aims to raise students' responsibility to explore their knowledge. In addition, verbal strategies are also carried out during manipulation and investigation. The lecturer suggests alternative ideas when students find it difficult to make decisions and control the progress of study groups in planning and conducting investigation activities (Savin-Baden & Major, 2004).

Study groups with diverse cultural backgrounds and cognitive skills facilitate students in developing their cognitive skills by sharing knowledge and experiences and help them to make adjustments to their environment (Griffin et al., 2012). The same goal to solve environmental problems with the basis of knowledge on local environmental management encourages students to discuss their prior knowledge with one another in class and link the ideas of all group members. Through the process of interactions and dialogs, students can make decisions to take action (Savin-Baden & Major, 2004).

Getting students used to study environmental problems that occur around them and to design solutions-oriented to local knowledge is pivotal in learning environmental science. Students master not only knowledge about the environment, but also skills to solve problems and foster the environment care attitude. Studying environmental problems facilitates students to get used to gathering information related to facts in the field. Based on the information obtained, students learn to develop opinions or determine attitudes towards environmental problems that occur. In addition, students are involved in linking various information about the environment, analyzing the interrelationships of causes and effects of environmental problems, and designing strategies in overcoming environmental problems (Palmer & Neal, 1994).

The integration of traditional or local knowledge in environmental science learning contributes positively (Kimmerer, 2012). First, students can get to know the traditions or habits of environmental management that have been practiced by previous generations. Second, students understand the benefits and importance of applying traditional environmental management practices to the current deteriorating environmental conditions (Brenner et al., 2013). Third, students gain new knowledge during the process of verifying the truth of local knowledge (Hiwasaki, Luna, Syamsidik, & Shaw, 2014). Fourth, students learn to integrate local and scientific knowledge to design innovative solutions (Makondo & Thomas, 2018; Torri & Laplante, 2009). Fifth, students contribute to preserving local environmental management practices as part of cultural wealth (McCarter & Gavin, 2011). Sixth, students learn to understand the meaning of sustainable living by applying traditional management practices (Dahliani, 2015; Sumane et al., 2017).

5. CONCLUSIONS:

Environmental literacy is an urgent demand given the current conditions of the environmental crisis. Environment care and its problems must be instilled in each individual because human is naturally an inseparable part of nature. Growing an attitude of caring for the environment must be done in concrete action. Education as a formal environment, for example, must be able to contribute to the generations that have insight into sustainable development. One strategy is to instill an environmental care attitude through learning. Interdisciplinary learning of environmental science must be able to empower students to be active in studying environmental issues, expressing opinions from a variety of perspectives, analyzing the interrelationships among environmental problems, evaluating the truth of information from various sources, and developing innovative strategies. Inquiry laboratory-based ethnosocioecology learning is one of the strategies to involve the active role of students as independent learners in building new knowledge. New knowledge is obtained by analyzing, linking, organizing prior knowledge with information being learned in the classroom, and the surrounding environment. Students deepen their understanding of environmental issues through investigations in the field, testing the truth of local knowledge, linking the concepts of local knowledge with the conditions of environmental problems, and designing appropriate strategies. Environmental science learning through real experience is not merely memorizing existing concepts. It also allows students to learn to dig up information, to communicate, and interact with peers and the surrounding community, and to argue based on the evidence. Studying the surrounding environmental problems and learning local knowledge practices in managing the environment, in addition to increasing knowledge about the environment, can also develop the cognitive skills of students in solving problems. Solving environmental problems is one manifestation of the environmental care attitude.

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Table 1. *Normality Test of Environmental Knowledge for 5 Cycles*

Cycle	Test	Mean	Standard Deviation	Sig.
1	Pretest	11.45	2.759	.200
	Posttest	22.86	2.489	.200
2	Pretest	12.79	2.513	.066
	Posttest	25.03	3.279	.090
3	Pretest	11.93	2.404	.200
	Posttest	25.79	2.366	.071
4	Pretest	12.38	2.128	.200
	Posttest	26.17	2.001	.190
5	Pretest	12.14	2.386	.200
	Posttest	26.83	2.606	.169

Notes:
Sig.: Significance

Table 2. *Homogeneity Test of Environmental Knowledge for 5 Cycles*

Cycle	Levene Statistic	Sig.
1	.480	.491
2	.709	.403
3	.004	.953
4	.025	.876
5	1.401	.242

Table 3. *Normality Test of Cognitive Skills for 5 Cycles*

Cycle	Mean	Standard Deviation	Sig.
1	10.07	1.602	.051
2	12.14	1.846	.200
3	12.45	1.617	.057
4	12.52	1.883	.200
5	13.34	1.696	.131

Table 4. *Homogeneity Test of Cognitive Skills*

Levene Statistic	Sig.
.435	.783

Table 5. *The Result of T-test*

Cycle	Test	Mean	Standard Deviation	Sig.
1	Posttest	22,86	2,693	0,000
	Pretest	11,45		
2	Posttest	25,03	2,214	0,000
	Pretest	12,79		
3	Posttest	25,79	2,912	0,000
	Pretest	11,93		
4	Posttest	26,17	1,934	0,000
	Pretest	12,38		
5	Posttest	26,83	2,020	0,000
	Pretest	12,14		

Table 6. *The Result of Pearson Correlation test*

Cycle	Variable	EK	CS	Sig.
1	EK		0,844**	0,000
	CS	0,844**		0,000
2	EK		0,937**	0,000
	CS	0,937**		0,000
3	EK		0,921**	0,000
	CS	0,921**		0,000
4	EK		0,933**	0,000
	CS	0,933**		0,000
5	EK		0,959**	0,000
	CS	0,959**		0,000

Notes:
EK: Environmental Knowledge
CS: Cognitive Skills
Sig.: Significance

APPENDIX

Questions to Measure the Environmental Knowledge

Cycle 1
1. Environmental science is multidisciplinary. For example, the problem of decline in fisheries productivity involves collaboration from various science experts to overcome it. Why is that?
2. Waste that pollutes the mangrove ecosystem area has an impact on increasing coastal abrasion. Besides, the decline in crab and shrimp productivity has a significant effect on the decline in income of the local community. What is the role of environmental science in efforts to improve the economic welfare of coastal communities?
3. Local people living on the slopes of Mount Lawu reject the plan to use geothermal energy to become a geothermal power plant. What factors underlying the rejection of the use of geothermal energy to be used as a geothermal power plant were assessed from the aspect of ethnosocioecology?
4. Land areas inhabited by local people have a high level of biodiversity. Why do cultural values play a role in protecting biodiversity?
5. Economic growth in Indonesia increase in 2018. Gross Domestic Product (GDP) reaches 5.17%, up from 5.07% from the previous year. Java Island still contributed to the growth of gross domestic product by 57.8% (the largest), followed by Sumatra by 23.4%. On the other hand, environmental conditions in Java, especially in densely populated areas, are already alarming. Likewise, the problem of land conversion continues to increase in Java and Sumatra. What is the impact of increasing economic welfare on the environment in Indonesia?
6. Currently air and water quality in almost all regions of big cities are very poor. Based on the results of the Ministry of Environment research, the air quality index in the DKI Jakarta area is the lowest (53.5) compared to other regions in Indonesia and far below the air quality index national level (87.03). In addition, DKI Jakarta's water quality index was 21.33 and DI Yogyakarta was 20.19. Both are far below the national water quality index which is equal to 58.68. Why is the problem of natural resources not free from population density?
7. How to use water more efficiently in the middle to upper-income groups in daily life?
8. What steps need to be taken so that the water supply continues to meet daily needs per person in all social strata?
Cycle 2
1. Java is the island with the largest population of 136.6 million people with a population growth rate of 1.21% per year over the period 2000-2010. Why is a densely populated area such as DKI Jakarta often there is a limited supply of resources?
2. BNPB showed that the conversion of forest land in Java to agricultural land can cause deviations from the principle of natural resources. Analyze the deviations in the principle of natural resources that occurred in the case.
3. Ecosystem management is an integrated approach that involves

	social, economic, ecological, and institutional perspectives. Why does ecosystem management need to involve various parties living around the ecosystem, resource users, decision-makers, people's representatives, and taxpayers?
4.	Decision making of environmental management policies needs to involve various parties. Why are local people as one of the important actors in making decisions about environmental management?
5.	Production forest management as one of the natural resource management policies involves communities around the forest to be able to apply the forest management paradigm and produce products based on local businesses that can compete and be accepted in the global market. Do you think that the policy meets the principles of environmental science?
6.	Social forestry management is a natural resource management policy to improve the welfare of life for indigenous and tribal peoples. Does the policy meet the four principles of environmental science? Explain your answer
7.	What is the action that must be taken by the community and the government if the watershed experiences a water quality crisis and habitat degradation due to land management for agriculture and animal husbandry that is not environmentally friendly?
8.	In 2001 the local government of Nagekeo, Kupang received a refusal from the local community to build the Lambo reservoir. What is the form of approach that should be used to form good cooperation in environmental management between local communities and the government?
Cycle 3	
1.	Why is the understanding of biocentrism considered insufficient as the highest guide in behaving and acting towards the environment as evidenced by the emergence of ecocentrism?
2.	Kemiren Village in Banyuwangi, East Java has the Sobo River and Gulung River which are to the south and north of the village and never dry throughout the year. Also, there is a spring that is protected and preserved by residents, namely the great-grandfather of Chile. One of the rules imposed is a ban on using source water on certain days and hours and cutting down trees around springs. Why do watersheds need to be managed properly without prioritizing human interests?
3.	What is the real form or example of anthropocentrism in daily activities that can have an impact on environmental damage (water/land area)?
4.	Kampung Naga people, Dayak, and Banjar tribes have a tradition of land distribution for residential zones, farming zones, protected zones, and sacred zones. Why do local land divisions and land use arrangements need to be preserved?
5.	Dayak tribes who live in Kalimantan implement a system of land rest in farming. Meanwhile, the people of West Kutai, East Kalimantan have implemented the Lembo System, which is a mixture of fruit forests and timber. Based on these examples, how can local knowledge apply the principles of environmental ethics?
6.	The division and arrangement of land is an example of local knowledge of Kampung Naga and Kampung Kuta, which consists of

	clean, sacred, and dirty areas. What is the principle of environmental ethics contained in this knowledge?
7.	Create a plan to purify the water based on the local knowledge of your home.
8.	Create a plan to increase the fertility of the land-based on the local knowledge available in your home.
Cycle 4	
1.	The food chain is composed of 4 trophic levels, namely 1-producer trophic level, trophic level 2-consumer 1 (herbivore), trophic level 3-consumer 2 (omnivore), and trophic level 4-consumer 3 (top predator). Why is there a level 2 consumer at the trophic level, omnivorous?
2.	In a food chain, there is an energy flow from one trophic level to another trophic level. Why the more trophic levels, the less amount of biomass?
3.	In the period of 2000-2014, Indonesia was recorded as a contributor to the loss of the largest mangrove forest in the world at 4,364 km2 or around 311 km2 per year. One of the threats to the decline in mangrove forests is the expansion of brackish water ponds in coastal areas for shrimp and milkfish commodities. How can brackish water ponds business affect the energy flow and material cycle?
4.	Based on a study conducted by the World Bank, coal extraction has a serious impact on the environment and communities around the mining area. Why does mining disrupt the phosphorus cycle and cause damage to freshwater ecosystems?
5.	The United States Department of Agriculture explains that globally 1/3 of human food is obtained from plants whose pollination is assisted by bees. In 2008, it was recorded that 36% of bee colonies were lost. The incident was caused by the use of pesticides. How is the impact caused by the decline in bee populations?
6.	The forest is a habitat for various animals that functions to stabilize local temperatures. Deforestation in Indonesia reaches 1.4 million hectares per year with the remaining 53 million hectares. Under these conditions, what will happen to the hydrological cycle?
7.	Carbon dioxide emissions from the power generation sector in China, especially by coal-fired power plants, were almost half of the total carbon dioxide emitters. What is your strategy to prevent increased carbon dioxide emissions?
8.	Phosphorus content in fertilizers can fertilize the soil, but continuous use can cause phosphorus cycle disruption. What strategies can be used in agricultural activities to prevent disturbance in the phosphorus cycle?
Cycle 5	
1.	The damage to coral reefs occurred due to climate change. From March to June 2016, the coral mortality rate reached 30-90% with coverage of NTT, NTB, southern Java, western Sumatra, north Bali, Lombok, Karimun Jawa, and Selayar. How can damage to coral reef ecosystems be fatal to human life and other living things?
2.	In 2012, land clearing for oil palm plantations covered an area of 276,246 Ha. Riau is a province that has the largest oil palm

plantations in Indonesia. How can land clearing for plantations affect the decline in the quality of the biotic and abiotic environment?
3. Based on scientific studies, there was a decline in food production in Indonesia by 4% over four times the El-Nino period (extreme drought). What is the relationship between global warming and the decline in agricultural productivity?
4. The availability of sufficient water will affect productivity, both in the goods and services sector. What is the relationship between decreasing water supply and poverty?
5. The Ministry of Environment and Forestry notes that at least 1.1 million hectares or 2% of Indonesia's forests have shrunk every year. What will happen to the biotic, abiotic, and socio-cultural environment if green land is diminishing?
6. The population dynamics have a very important influence on ecosystems, including those related to water availability. How can the population affect the fulfillment of clean water needs?
7. Make a plan to solve environmental problems due to organic and inorganic waste at the household scale.
8. Make a plan to overcome the problem of water pollution in household-scale consumption.