The implementation of ESD into Biology learning to equip students with ESD competencies of systemic thinking and problem-solving

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Abstract. The purpose of this study is to equip students with ESD competencies of systemic thinking and problem-solving in the topic of environmental change. The weak experimental method with the one-group pretest-posttest design was used for this study. Twenty-nine students were selected by purposive sampling in grade X Public High School I Bandung. Data was collected through instruments written tests. Each test was arranged based on the indicator of systemic thinking and problem-solving that have integrated with the aspect of ESD (social, environment, and economy). Data was tested by N-Gain. Based on the results of the N-Gain category on student systemic thinking ability were high (0%), medium (48.27%), and low (51.72%). And then, the results of the N-Gain category on student problem-solving ability were high (0%), medium (72.41%), and low (27.58%). The result test of pretest-posttest scores of students’ systemic thinking ability showed an average of 69.13 and 80.03. Then, the result test of pretest-posttest scores of students’ problem-solving ability showed an average of 61.48 and 79.03. It can be concluded that the effort to implement ESD in Biology learning was quite successful in equipping students’ thinking systems and problem-solving skills.

1. Introduction
Education for sustainable development is a dynamic concept that encompasses a new vision of education to empower people to assume responsibility for creating a sustainable future. Its overall aim is to empower citizens to act for positive environmental and social change implying a participatory and action-oriented approach [1]. Education enables us to understand ourselves and others, and our links with the wider natural and social environment; and this understanding serves as a durable basis for building respect.

Along with a sense of justice, responsibility, exploration and dialogue, ESD claims to move us to adopt behaviors and practices that enable us to live a full life without being deprived of basics. So, we hope education at all levels can shape the world of tomorrow, equipping individuals and societies with the skills, perspectives, knowledge, and values to live and work sustainably. It directly affects
sustainability plans in the following areas: (1) implementation, (2) decision making, (3) quality of life [2]. Education is a tool to achieve sustainable development goals. So, it's very important to integrate sustainable development into education, and we call it Education for Sustainable Development (ESD). ESD is the core of teaching and learning, so it should not be considered as an addition to the existing curriculum [3]. ESD in the Education unit can be done by integrating into curricular activities (subjects) and extracurricular activities (scouting, cultural arts, etc.) [4]. For ESD to be more effective, educational institutions as a whole must integrate the principles of sustainability into their daily practice and facilitate the development of ESD, competency development, and comprehensive value education, as well as in all formal education curricula, including early childhood education, primary and secondary education, technical and vocational education, training, and higher education contain learning outcomes related to sustainability [5]. Indicative curricular themes can also be used and adapted as 'entry points' to develop ESD [6].

Besides, skills also are essential in the development of ESD, students need to have skills of ESD [6]. The skills needed to develop ESD are systemic thinking, anticipatory, normative, strategic, collaboration, critical thinking, self-cultivation, integrated problem solving [7]. Systemic thinking is one of the abilities that needed to investigate and analyze the components of the ESD. Because ESD is a system that has interconnected system components [8]. Systemic thinking involves the ability of observation at various scales [9]. The ability of systemic thinking will help students to be able to make the right decisions and solutions. A person who is poorly trained to think systematically (even highly educated adults) will tend to have a one-way perspective, focus on a narrow causality chain and fail to capture the impact of an action. Someone who cannot think systematically will find it difficult to find solutions to a specific problem [9]. The process to think systematically can be the right framework for developing problem-solving abilities and guide students to deal with uncertainty in their lives. This competency is closely related to students to solve simple problems in their environment and society, and then students can solve complex sustainability problems [10].

The topic of environmental change in the Biology national curriculum is one of the important themes or issues raised by UNESCO as an important problem that must be resolved by all humans on earth for human survival. Understanding the topic of environmental change from the perspective of sustainable development is very important for students as citizens of the world, so students have the awareness and responsibility to care for and care for the environment, as well as participate in reducing the impacts of disasters that occur. The implementation of ESD into Biology learning is expected to equip students with ESD competencies. In Indonesia, sustainable development is a mandate of laws and regulations that must be applied in all levels of society. Future development must be carried out into academics and not just as a policy. So that every teacher must be able to implement sustainable development education into learning. But, based on my experience at school as a teacher, the researcher also found problems in the form of Biology learning activities that did not refer to environmental and social community phenomena, and when I asked teachers, they did not fully understand ESD and how ESD is integrated into Biology learning. Through this phenomenon, so then the researcher conducted a study about the implementation of ESD into Biology learning to equip students with ESD competencies of systemic thinking and problem-solving.

2. Methods
The study was conducted from January 2020 to April 2020 in a High School I Bandung, Bandung City, West Java, 40132, Indonesia. The weak experimental method with the one-group pretest-posttest design was used for this study [11]. This type of research was chosen because the researcher wanted to focus on direct and detailed observations on the implementation of ESD in one class. The subjects of this study were grade X, twenty-nine students were selected by purposive sampling. Data was collected through instrument written tests, the test of systemic thinking consisting of 6 essay questions, and the test of problem-solving consisting of 7 essay questions. Each test was arranged based on the
indicator of systemic thinking [12] and problem-solving [13] that have integrated with the aspect of ESD (social, environment, and economy). Research procedures and stages include: 1) Literature study, 2) Formulation problems and preparing proposals, 3) Consultation with experts and advisor related to ESD and Biology learning 4) Formulation Integrated courses (social, environmental and economic aspects) on environmental change material, 5) Preparation of ESD learning indicators on environmental change material, 6) Development of ESD lesson plans on environmental change material, 7) Preparation instruments of systems thinking and problem-solving under ESD indicators, 8) Revised research instruments and revised lesson plans, 9) Judgment instruments, trials, and analysis of research instruments, 10) Determination subject and pretest, 11) Implementation of ESD learning, 12) Posttest, 13) Data processing and analysis, 14) Results.

3. Result and Discussion

3.1. Table 1. The N-gain category of students’ systemic thinking ability

Table 1 shows the N-gain category of students’ systemic thinking ability. The N-Gain category on student systemic thinking ability were high (0%), medium (48.27%), and low (51.72%), which means the interpretation of the N-Gain value was low, so it can be said that the implementation of ESD into Biology has a low effect on students' systemic thinking ability. It can be seen that students have not been able to determine the ESD components that exist in the surrounding environment and society. It can be assumed that students have not been taught to identify aspects of ESD that exist in the environment and surrounding communities. Students haven't realized or comprehended that they are part of a system that affects environmental, societal, and economic conditions both locally and globally. They have not been able to recognize the complexity of problems and look for connections and synergies in complex problems [14].

| Systemic Thinking Category | N-Gain (%) | Average N-Gain (%) | Category |
|----------------------------|------------|--------------------|----------|
| High                       | 0          | 29.8               | Low      |
| Medium                     | 48.27      |                    |          |
| Low                        | 51.72      |                    |          |

Data of students systemic thinking were taken by using an instrument consisting of 6 essay questions. Indicators of systemic thinking that were used in a test of systemic thinking ability are; 1) identifying system components in the discourse, 2) arranging components in the form of cycles, charts, or schemes, 3) explaining the relationships between components, 4) identifying interactions between components, 5) using data to predict changes that occur, 6) generalizing phenomena that happens. Data of students systemic thinking was taken by using an instrument consisting of 6 essay questions. Systemic thinking indicators used in students' systemic thinking tests are; 1) identifying system components in the discourse, 2) arranging components in the form of cycles, charts, or schemes, 3) explaining the relationships between components, 4) identifying interactions between components, 5) using data to predict changes that occur, 6) generalizing phenomena that happens. Based on the results of the calculation of the average value of students systemic thinking in pretest and posttest activities obtained by 69.13 and 80.03, from these values, it can be seen that there was an increase in the value
of students’ systemic thinking ability after learning. The lowest and highest system thinking ability values in the pretests obtained were 47 and 83, while the lowest and highest scores in the posttest obtained were 70 and 86. Then the gain normality test was carried out to get a general picture of increasing scores of the ability of students systemic thinking between before and after ESD was integrated into Biology [15].

3.2. Table 2. The N-gain category of students’ problem-solving ability

Table 2 shows the N-gain category of students’ problem-solving ability. The N-gain category on student problem-solving ability were high (0%), medium (72.41%), and low (27.58%), which means that the interpretation of the N-Gain value was medium, so it can be said that implementation of ESD into Biology learning has a medium effect on students’ problem-solving ability [15]. Based on the observation during learning, students already can think of simple ways to solve existing problems in the surrounding environment. It’s just that they have not been able to systematically design tools to solve problems. They have difficulty imagining how the tool works. This was, perhaps because students at the secondary school level are less taught manual skills in designing tools. This needs to be considered, for current needs, maybe students need to be trained with manual skills in designing problem-solving tools into learning Biology.

| Problem solving Category | N-Gain (%) | Average N-Gain (%) | Category |
|--------------------------|------------|-------------------|----------|
| High                     | 0          | 40.9              | Medium   |
| Medium                   | 72.41      |                   |          |
| Low                      | 27.58      |                   |          |

Data on the results of students’ problem solving were taken by using an instrument consisting of 7 essay questions. Indicators of problem-solving that were used in a test of problem-solving abilities are; 1) identifying problems, 2) making questions based on the identified problems, 3) making alternative solutions to problems in the discourse, 4) choosing the best alternative solutions, 5) using data to analyze environmental changes due to human activities, 6) evaluating solutions based on the results of trials, 7) analyzing the positive and negative impacts on social, environmental and economic aspects from the solutions made. Based on the results of the calculation of the average value of students pretest and posttest obtained by 61.48 and 79.03, from these values it can be seen there was an increase in the value of students’ problem-solving ability after learning. The lowest and highest of pretest scores were obtained 43 and 83, while the lowest and highest posttest scores were 70 and 87.

These ESD competencies will be a tool for students to use their knowledge, skills, perspective, insight, and understanding to deal with new situations [16]. A good understanding of ESD, student’ systemic thinking, and problem-solving that they have, specifically will enable students can overcome problems in their lives [17] and will be the basis for students facing globalization [18]. These competencies will also improve students’ analytical skills in understanding of ESD [19]. In the long run, Students that have ESD competencies are expected to have awareness of environmental, socio-cultural, gender, human rights, mitigation, development as well as about a sustainable future in Indonesia [20]. All of these skills are expected to not only make students survive in uncertainty, however, prepare students to be an inventor. They realized that the small things they do every day can have an impact and make the world a better place. They can accept the existence of diversity, gender,
ethnicity, religion, etc as good things and influence each other. So that, people must unite to maintain the nature to survive.

4. Conclusion

Based on the results of the N-Gain category on student systemic thinking ability were high (3.44%), medium (48.27%), and low (48.27%). And then, the results of the N-Gain category on student problem-solving ability were high (6.89%), medium (65.51%), and low (27.58%). The result test of pre-test post-test scores of students’ systemic thinking ability showed an average of 69.13 and 80.03. Then, the result test of pre-test post-test scores of students’ problem-solving ability showed an average of 61.48 and 79.03. It can be concluded that the effort to implement ESD in Biology learning was quite successful in equipping students' thinking systems and problem-solving skills. This study can provide a general description for teachers about the ability to think systems and problem-solving students towards ESD integrated Biology learning on environmental change material. This research also provides information on how to equip students with ESD competencies. Teachers can also try to involve other ESD skills that are suitable for the Indonesian region in Biology learning.

5. References

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