Citizen Science: Fostering Creative Thinking in Environmental Education

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Abstract. This study aimed to investigate the effectiveness of Citizen Science in improving the creative thinking abilities of grade 6 elementary school students in addressing environmental pollution. A total of 50 students were divided into an experimental group that used Citizen Science and a control group that used learning prepared by the Ministry of Education and Culture. The N-Gain score was used to measure the improvement of the students' creativity. The results showed that the experimental group had a higher N-Gain score of 59.56, indicating medium improvement, compared to the control group with a score of 21.17, indicating low improvement. These findings suggest that Citizen Science can be an effective approach to improve students' creative thinking abilities and should be considered in environmental education.

Keywords: Citizen Science · STEM Learning · Creative Thinking Skill

1 Introduction

1.1 Background

Environmental problems are now increasingly becoming an issue that is always being discussed and has yet to find common ground not only in Indonesia, but also in the world [1]. Environmental issues are also a major concern of the United Nations Development Program (UNDP) in the Sustainable Development Goals (SDGs). One example of environmental problems in Indonesia is water pollution. Based on data from the Indonesian Center for Environmental Law [2], water pollution in Indonesia is caused by human activities that leave residential waste, agricultural waste, and industrial waste including mining. Even the Asian Development Bank [3] states that water pollution in Indonesia causes a loss of Rp. 45 trillion per year. This loss is caused because the state has to bear the costs of health, clean water, tourism, and infant mortality.

Seeing the condition of environmental problems and environmental literacy skills in Indonesia, a question arises regarding the effectiveness of the environmental pollution learning system established by the government, especially the Ministry of Education and Culture so far. Learning about environmental pollution in Indonesia is found in Class

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Table 1. Research Design.

Group	Pretest	Treatment	Post Test
Experiment	Completion of test questions about students' creative thinking skills	Learning about environmental pollution using the application of Citizen Science	Completion of test questions about students' creative thinking skills
Control	Completion of test questions about students' creative thinking skills	Learning environmental pollution using conventional (which is done in everyday learning)	Completion of test questions about students' creative thinking skills

VI Natural Sciences lessons issued by the Ministry of Education and Culture of the Republic of Indonesia in Permendikbud no. 37 of 2018 [4].

The absence of science learning, especially on the topic of environmental pollution which involves creativity in elementary school students causes the possibility of their unpreparedness in facing future needs which is often called the Industrial Revolution 4.0 where all sectors will involve Science, Technology, Engineering, and Mathematics (STEM) in operation. As is currently happening, especially in Indonesia, many graduates have difficulty finding jobs because the quality of supply from graduates and the demand that companies need do not meet [5].

To reconcile supply and demand which is the current problem, Citizen Science which is an authentic learning that involves citizens participating in a project by carrying out scientific processes [6] is expected to be a solution. The research entitled Authentic science with citizen science and student-driven science fair projects, it shows that applying Citizen Science to high school students provides an opportunity to become more familiar with professions in the STEM area because in practice they work with the experts, besides that they also have a better understanding of science learning, especially in discussing environmental pollution. However, in this study it has not been implemented for elementary school students and has not implemented learning that involves creative thinking skills in Citizen Science activities.

2 Methods

2.1 Research Methods and Design

This study used a quantitative approach with a quasi-experimental method through a matching-only pretest–post test control group design [7]. This study was used to measure students' creative thinking skills after the Citizen Science learning was implemented.

There are two experimental and control groups involved in this study. The randomization step was omitted because it was not possible to randomize the participants into two groups. Therefore, the groups in this study will be formed beforehand. The design of this study is shown in Table 1.

This research was conducted by involving the experimental and control groups. The experimental class applies environmental pollution learning using Citizen Science with samples sought by students in the form of site conditions (precipitation, air temperature, and photo evidence of the surrounding environment), water quality data (water temperature and pH) and macro invertebrate data at their respective residences. Respectively, while the control class applies environmental pollution learning using conventional learning carried out in everyday learning on the topic of environmental pollution. The pretest and post test were given to students consisting of a description test of students' creative thinking skills.

This study uses a pretest and post test design to show the effect of citizen science learning on creative thinking skills so that students can become future generations who will solve environmental problems in the world.

2.2 Research Participants

This study selected samples using a convenience sampling technique in which the study was conducted in 2 classes (experimental and control classes) in one school that provided access to conduct research. Participants in this study were 6th grade elementary school students in schools that used the 2013 curriculum in learning science. The selection of participants was based on the consideration that the topic of environmental pollution used in this study was based on the 2013 Curriculum made by the Ministry of Education and Culture.

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2.4 Research Instruments

Learning Achievement Observation Format

To ensure that learning is carried out according to the target, it is necessary to observe the learning process. Table 2 shows a grid of this observation format based on the stages of learning activities with Citizen Science learning [8].

To achieve learning with Citizen Science learning, research uses the EarthEcho Water Challenge website. EarthEcho Water Challenge (formerly World Water Monitoring Challenge) is an international program that runs annually from March 22 (United Nations World Water Day) to December and anyone can complete data to protect the water resources they rely on every day. The EarthEcho Water Challenge builds public awareness and engagement in protecting water resources around the world by engaging citizens to carry out basic monitoring of local water bodies.

Table 2. Research Design.

Citizen Science Stages	Aspects of Creative Thinking Skills
Define a research question or problem	Flexibility
Gather information	Elaboration
Develop a hypothesis	Fluency
Designing data collection methods regarding the problem	Flexibility
Sample data collection	Elaboration
Analyze samples	Elaboration
Analyze aggregated data	Elaboration
Interpret aggregate data and conclusions	Fluency
Dissemination of results / translating them into action in the form of ideas or products by thinking of designs, drawing plans, making designs, and testing designs	Originality
Discuss results and formulate new questions	Originality

Problem Description of Students' Creative Thinking Skill
This description question includes questions about fluency thinking skills, flexibility thinking skills, original thinking skills and detailed thinking skills (elaboration). The description of creative thinking skills used in this study is in the form of essay questions. The questions cover four aspects of the ability to think creatively. The items describing the ability to think creatively were prepared by the researcher and then consulted with the supervisor and validated by the expert judgement, then tried out to measure the reliability of the test, discriminating power and the level of difficulty of the test.

3 Results and Discussion

3.1 Implementation of Citizen Science in Learning Environmental Pollution

The research was conducted in three meetings where the first meeting was in the experimental class giving pretest creative thinking skills, setting research questions or problems, gathering information, developing hypotheses, and designing data collection methods; the second meeting students are given experience to collect sample data, analyze samples, analyze aggregate data, and interpret aggregate data; and at the third meeting students disseminate results in action in the form of ideas by thinking, drawing, making, and testing designs, discussing results and compiling new questions, giving post-tests for creative thinking skills.

Whereas in the control class at the first meeting students were given a pretest for creative thinking skills, then the learning stages consisted of the preliminary, content, and closing stages. At the second and third meetings, the learning stages were the same. However, at the third meeting students were given a post test for creative thinking skills.

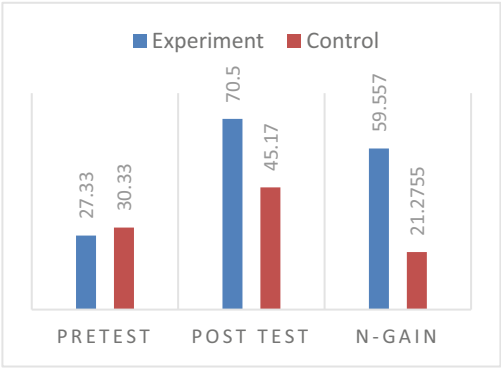

Fig. 1. Students' Creative Thinking Skill Result between Experiment Group and Control Group

3.2 The Effect of Citizen Science Learning on Environmental Pollution Learning on Students' Creative Thinking Skills

The N-Gain between experiment group and control group to see the significant. The average score of students' creative thinking skills in learning environmental pollution in pretest and post test (see Fig. 1).

Based on Fig. 1 the average score of pretest in experiment group and control group is 27.33 and 30.33. The average percentage of post test in experiment group and control group is 70.5 and 45.17. The analysis of N-Gain in experiment group and control group shows if the method that was treated in both group give the impact on improvement of students' creative thinking skill in learning environmental pollution. The N-Gain score from experiment group is 59.557 which categorized as medium improvement and control group is 21.2755 which categorized as low improvement.

4 Conclusion

Based on the result of this research, it conclude that there is significant difference on students' creative thinking skills between experiment group which learn using Citizen Science and control group. The implementation of Citizen Science in learning environmental pollution is good to be used.

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References

1. WALHI. (2021). Kondisi Lingkungan Hidup di Indonesia di Tengah Isu Pemanasan Global. https://www.walhi.or.id/kondisi-lingkungan-hidup-di-indonesia-di-tengah-isu-pemanasan-global

2. Indonesian Center for Environmental Law. (2018). Pemulihan Harus Dimulai dari Penanganan Limbah Industri. https://icel.or.id/berita/pemulihan-harus-dimulai-dari-penanganan-limbah-industri/
3. Asian Development Bank. (2011). Annual report. Annual Report., 1. https://doi.org/10.5962/bhl.title.42736
4. Permendikbud. (2018). Permendikbud RI Nomor 37 tahun 2018 tentang Perubahan atas Peraturan Menteri Pendidikan dan Kebudayaan Nomor 24 tahun 2016 tentang Kompetensi Inti dan Kompetensi Dasar Pelajaran pada Kurikulum 2013 pada Pendidikan Dasar dan Pendidikan Menengah. JDIH Kemendikbud, 2025, 1–527
5. Pratiwi, R. (2013). Analisis Faktor Yang Mempengaruhi Lama Mencari Kerja Lulusan Sekolah Menengah dan Pendidikan Tinggi di Indonesia Pada Tahun 2012. SSRN Electronic Journal, 1(2), 99–117. http://www.eldis.org/vfile/upload/1/document/0708/DOC23587.pdf%0Ahttp://socserv2.socsci.mcmaster.ca/~econ/ugcm/3ll3/michels/polipart.pdf%0Ahttps://www.theatlantic.com/magazine/archive/1994/02/the-coming-anarchy/304670/%0Ahttps://scholar.google.it/scholar?
6. Koomen, M. H., Rodriguez, E., Hoffman, A., Petersen, C., & Oberhauser, K. (2018). Authentic science with citizen science and student-driven science fair projects. Science Education, 102(3), 593–644. https://doi.org/10.1002/sce.21335
7. Fraenkel, J. R., Wallen, N. E., & Hyun, H. H. (2012). How to Design and Evaluate Research in Education.
8. Bonney, R. (2009). Public Participation in Scientific Research: Defining the Field and Assessing Its Potential for Informal Science Education. July.