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Scientific Communication of Pre-service Biology Teachers Using Engineering Design Process on Environmental Pollution Concepts

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Abstract

The Engineering Design Process (EDP) is a decision-making process, usually iterative, in which basic science, mathematics, and engineering concepts are applied to develop optimal solutions to achieve established goals. The stages in EDP include identifying problems, finding solutions, designing solutions through designs or models, and creating and testing models. The design component includes developing student creativity, open problems, and development and utilization. Scientific communication refers to expressing ideas and information clearly and meaningfully. Communication has four primary purposes: to inform, instruct, motivate, and advise others. This research examines the scientific communication of Pre-service Biology Teachers using EDP regarding environmental pollution. The instrument used is a scientific communication observation sheet consisting of information retrieval, scientific reading, listening and observing, scientific writing, information representation, and knowledge presentation. This assessment sheet assesses students' work on written scientific communication and videos on oral scientific communication. This research indicates that EDP can initiate scientific communication among pre-service biology teachers on environmental pollution. Pre-service Biology Teachers can implement it well, from identifying problems to finding solutions, designing solutions in the form of designs or models, and creating and testing models. The highest level of scientific communication is in information retrieval and representation indicators.

Keywords: Scientific Communication, EDP, Environmental Pollution, 21st Century Skills

INTRODUCTION

Science, technology, and industry have resulted in rapid digitalization and modernization in various fields. These developments will affect human life, one of which is in the education sector. Every individual must be able to follow these developments to survive in the 21st century. In realizing the Industrial Revolution Era 4.0, there needs to be a balance between knowledge and skills as the basis for quality human resources in current developments (Mardhiyah et al., 2021; Rhedana, 2019; Masfufah, 2022). 21st-century learning not only demands the 4C skills (collaboration, communication, creative thinking, and critical thinking) but also must be able to master the 6C skills, namely compassion and computation (Sari et al., 2021). These 6C skills can be developed in Science, Technology, Engineering, and Mathematics (STEM). STEM needs to be developed and implemented in the education curriculum so that students not only understand the concepts but also that all students' skills and abilities can be well honed in the learning process.

One way to implement STEM is by integrating it with the Engineering Design Process (EDP). The application of EDP goes through the stages of formulating questions, imagining, planning, creating, testing, analyzing, concluding, communicating, and developing (Setiawan, 2020). Students can learn to analyze situations and collect relevant information, define problems, evaluate, and generate creative ideas, develop ideas to solve problems effectively and evaluate and improve the solution by learning the Engineering Design Process (Syukri et al., 2018). These abilities and skills need to be directed at students to achieve educational goals and produce quality human resources who can adapt and compete in various conditions faced in the future.

Lecturers must develop their potential to increase their quality professionalism and update teaching materials, models, and learning media by the 21st century. Communication is one of the 21st-century skills that is important for Pre-service Biology Teachers. Communication skills are something that a person must have because communicating will make it easier to convey information, express desires and feelings, and actualize what is within oneself (Nurmala & Priantari, 2017; Sari et al., 2019; Martiani et al., 2021). Communication can be done verbally or in writing. Students can convey ideas from observations through presentations, observation reports, and sharing via social media and other media.

Technological advances in various fields will have positive and negative impacts, namely in the form of environmental pollution and damage, ultimately resulting in a decrease in quality or environmental degradation. Banten is one of the provinces that experiences environmental damage, pollution, and degradation in almost every district and city. These environmental problems include decreasing surface water quality (surface water pollution), disruption of aquatic biota as a derivative impact of surface water pollution, decreasing air quality (air pollution) and increasing noise, decreasing environmental aesthetics and the smell of rubbish, and saltwater intrusion into land areas. (increased groundwater salinity), decreased water quantity in receiving bodies and groundwater, erosion, damage or extinction of mangrove forests, damage to coral reefs, damage to coastal ecosystems due to abrasion, damage to river ecosystems due to silting and flooding, land damage and deforestation (Provincial et al., 2014). Based on the background above, it is essential to carry out this research to analyze the scientific communication of Pre-service Biology Teachers using the Engineering Design Process (EDP) on the concept of Environmental Pollution.

METHOD

The method used in this research is the case study method. The case study method explores in-depth data collection and involves information sources in a context (Creswell, 2007). This research was carried out by implementing an Engineering Design Process (EDP) oriented towards 21st-century skills (scientific communication) in overcoming environmental pollution in Banten. The sample used was 2nd-semester Biology Education students, totaling 30 students. The sample was selected by purposive sampling. Data collection is carried out through observation, questionnaires, and documentation. This research will be carried out from April to October 2023 at Sultan Ageng Tirtayasa University, and implementation activities will be carried out in several areas of Banten Province.

Research uses the EDP technique to identify problems, find solutions, design solutions through designs or models, and create and test models. The EDP stages were analyzed for their implementation, and then scientific communication skills were measured after observations were made about environmental pollution that occurred in the environment around Serang-Banten. The scientific communication instruments used are as follows in Table 1.

Table 1. Aspects and indicators of scientific communication

No.	Aspects	Indicators of Scientific Communication Achievement
1	Obtaining information	Information retrieval Scientific reading Listening and observing
2	Submit information	Scientific writing Information representation Knowledge presentation

Source: (Levy, 2008)

RESULTS AND DISCUSSION

Pre-service Biology Teachers can adapt and compete with future needs by having skills in science, technology, engineering, and mathematics (STEM). One way to create individuals who suit these needs is to implement the Engineering Design Process (EDP) in solving a problem. In Banten, several areas have been recorded as experiencing high pollution levels in the air and water. The potential for pollution in the Cibanten River and Situ Cipondoh is high. The high pollution level is caused by the high potential for polluting waste entering from land and household waste, increasing the pollution burden from year to year (Banten Provincial Government Environment and Forestry Service, 2020). By implementing the Engineering Design Process, oriented towards

21st-century skills, students are directed to overcome environmental pollution in Banten. The EDP learning model is a learning model that improves students' ability to solve problems. EDP is a learning model teachers can use to improve problem-solving abilities in learning and introduce engineering discipline to students (Ulum et al., 2021).

Learning is carried out in groups; students are instructed to analyze, study, and then plan creative solutions to resolve the pollution problems found. EDP is implemented in 21st-century skills, one of which is communication skills. Communication skills are essential to success in learning; students will easily communicate various things related to learning material, both orally and in writing (Hamia et al., 2021). Communication skills assessment is carried out from the beginning to the end of the learning process using observation sheets with indicators for information retrieval, scientific reading, listening and observing, scientific writing, information representation, and knowledge presentation.

Based on the results of the analysis, data was obtained that the scientific communication of Pre-service Biology Teachers for each indicator was as follows:

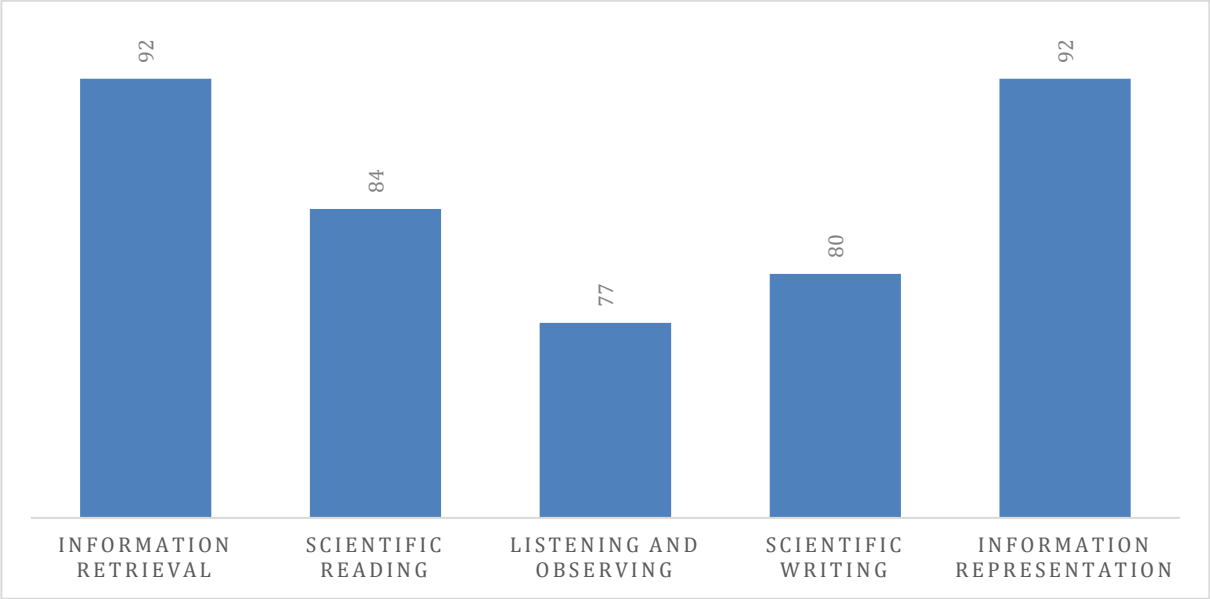

Figure 1. The value of scientific communication for each indicator

Figure 1 shows that 92% of pre-service biology teachers have information retrieval abilities in the first indicator of scientific communication skills. This is proven by students using references from several sources, such as printed books, interviews, articles, and scientific journals. Students use these references at the EDP stage (identifying problems, finding solutions, designing solutions). When identifying problems, students observe the polluted environment by directly interviewing

residents and conducting literature studies. When finding solutions, students look for literature related to problems that occur in other places and look for alternative solutions that are appropriate for the problems they face. The application of EDP-Problem Solving Project learning is carried out on environmental pollution. It focuses on student activities to overcome environmental pollution from shallot farming (Setiawan, 2020). At the solution design stage, students make presentation materials about pollution cases, describe the polluted surrounding environment, and provide alternative solutions with various designs, such as making policies about waste, using sophisticated equipment to transport waste, and using tools to process waste. Applying the Engineering Design Process (EDP) using a STEM approach creates creative thinking. It allows students to develop problem-solving processes that are solutions in the real world (Nusyirwan et al., 2020). Through this presentation, awareness will arise within oneself to start loving and protecting the environment from pollution. Communication plays a significant role in disaster communication campaigns due to environmental crises such as the Citarum watershed (Zakaria & Dwianti, 2021).

In the second indicator of scientific communication skills, 84% of students have scientific reading skills. It is proven that students use accurate and relevant library sources in making observation reports through student worksheets. In choosing a bibliography as a reference source, students must be selective according to the main issues discussed in the scientific work of students, lecturers, and other research staff (Djunaidi, 2017). Students use library sources to answer cases of environmental pollution problems. The selection of information sources used by students to support academic activities is adjusted to their needs, and the selection of literature is based on the type of activity they undertake. Students tend to use technology-based sources (Prajawinanti, 2020). Four pollution cases were given, including water pollution in rivers, piled-up rubbish pollution, factory waste pollution, and vehicle noise pollution.

In the third indicator of scientific communication, 77% of students can listen and observe. Listening helps to build trust, ensures support, confirms what is being discussed, and is an effective way to gather information (Aminah, 2018). It is proven that students listen to other friends when speaking and can respond well, such as answering questions, asking questions, expressing agreement, and expressing disagreement. Listening skills are an active and creative listening activity to obtain information, capture content, and understand the meaning of the speaker's message through speech or spoken language (Sukma & Syaifudin, 2021). At the EDP implementation stage, students are asked to submit the results of observations in the surrounding environment experiencing pollution. The report presents information from observations or research

investigations in the form of facts made in systematic language (Perayani, 2020). Students in each group take turns presenting the results of identifying problems that occur in polluted environments, exploring the causes of pollution problems, and analyzing alternative solutions to the pollution that occurs. Students are active in asking questions and providing responses during discussions and presentations.

In the fourth scientific communication indicator, 80% of students have the ability in scientific writing. Writing scientific papers is useful for improving reading and writing skills, practicing integrating various ideas and presenting them systematically, and broadening scientific horizons (Rahim, 2020). This is proven because students can compile and convey information through a resume. At the EDP stage, students in groups write down the results of observations of the polluted environment using worksheets. Individually, students will write them in the form of a resume. On the resume, students can record various things obtained from the results of presentations presented by other groups. Making summaries of learning material involves a cognitive process that allows students to integrate the knowledge they already have (Ismail, 2017).

92% of students have information representation abilities in the fifth scientific communication indicator. Knowledge must be represented efficiently and provide meaning and value that can be used by intelligent systems that need it (Suputra, 2010). It is proven that students can create and convey information through tables of observation results. Students make reports of observations on polluted environments using tables. A table is a list containing a large amount of information data in words and numbers arranged in a sequential system so that students can easily read and understand the information presented (Nuryadi et al., 2017; Permatasari, 2020). The table contains information about identified pollution problems, problem identification analysis, problem cause exploration, problem cause exploration analysis, solution alternative exploration, and solution alternative analysis. Students' communication skills will provide an atmosphere that supports active learning because students will have confidence in expressing their arguments and become a means of developing an empathetic attitude in respecting differences of opinion that they will find in the community (Marfuah, 2017).

In the sixth scientific communication indicator, 82% of students have knowledge presentation skills. It is proven that students are fluent in expressing opinions, using flexible body language, and being flexible. At the EDP stage of creating and testing models, students make videos about pollution in the surrounding environment. In order to make EDP easy to understand, a learning video was developed, which contains a guide to using the module, such as a video tutorial

(Widiastuti & Budiyanto, 2022). Students in groups create model designs based on the results of observations. Mastering EDP means students learn and understand what an engineer does, namely solving problems through design (Nusyirwan et al., 2020). In the video, students convey the problems that occur in polluted environments by interviewing residents directly and conveying their opinions regarding solutions that can be used to overcome problems in polluted environments.

Based on the data above, applying the Engineering Design Process (EDP) in the learning process can develop 21st-century skills, namely the communication skills of Pre-service Biology Teachers. Developing 21st-century skills needs to be supported by 21st-century learning, which can be taught and integrated into the curriculum by providing exciting learning opportunities and carrying out challenging activities (Muttaqin, 2023). Students implement it well by identifying problems, finding solutions, designing solutions in the form of designs and videos, and creating and testing them. The benefit of communication skills for students in the learning process is that they help students understand the information and messages provided in the form of lesson material (Fitriah et al., 2020).

CONCLUSION

Based on the research results, the Engineering Design Process (EDP) can initiate scientific communication on environmental pollution among pre-service biology teachers. Pre-service Biology Teachers can implement it well, from identifying problems to finding solutions, designing solutions in the form of designs or models, and creating and testing models. The highest level of scientific communication is in information retrieval and representation indicators.

SUGGESTIONS

Based on the research results, researchers provide recommendations for expanding the scope of polluted environmental observation locations and measuring other components of 21st-century skills.

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