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Prospective biology teachers' cognitive perceptions about the concept of pollution

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Abstract

The perceptions of students who study environmental science related to pollution are certainly different because they are influenced by various circumstances. These circumstances, among others, depend on what they observe around them and their prior knowledge. This study aimed to determine the concept of pollution according to the cognitive structure of prospective biology teachers. The research was designed as a case study and the selected participants were 29 first-year biology education students who took environmental science courses. Data were collected by giving word association tests, open-ended questions, and drawings. The results showed that students' thinking process and prior knowledge influenced their ability to express ideas or answers. Cognitive perceptions of prospective biology teachers from the word association test brought up 30 words related to the pollution which were grouped into four categories, namely types of pollution, causes of pollution, consequences of pollution, and solutions to overcome pollution. Cognitive perceptions of prospective teachers based on open-ended questions, most of them wrote the definition of pollution as stated in the environmental management law, and cognitive perceptions of prospective teachers outlined in the form of drawing related to efforts to overcome pollution are throwing garbage in its place, doing reforestation, and go green action.

Keywords: cognitive perception, environmental issues, pollution.

Introduction

Environmental problems are currently a major problem that threatens human life (Marpa et al., 2016) making it a topic of discussion and attention of the international community. Climate change, global warming, the greenhouse effect, acid rain, waste, glacier melting, air pollution, water pollution, and soil pollution are some of the environmental problems that arise due to various factors (Cenap Yologlu, 2020; Soares et al., 2021). When it is traced, humans are the most responsible party for having negative effects due to their interaction with the environment (Marques & Xavier, 2020).

One of the environmental problems that is in the spotlight and often comes to a person's mind is pollution. Rinkesh (2016) emphasized that pollution is one of the crucial environmental problems besides global warming, biodiversity decline, population explosion, and ozone layer depletion. Future generations need to be aware of global issues that affect the lives of humans and train them to be responsive individuals in solving related problems starting from home and continuing in educational institutions that will not stop for a lifetime (Kayaalp et al., 2021). Students starting from the elementary school level should obtain information related to environmental issues comprehensively. Educational institutions are expected to contribute to learning related to the environment. Atasoy (2017) revealed that learning about the environment can reduce environmental problems that have increased in recent years. This learning raises awareness and also responsibility for environmental problems and plays an active role in protecting the environment (Leicht et al., 2018). In addition, education can be used as an individual process in order to develop knowledge, behavior, and skills in solving environmental problems.

Various kinds of literature related to environmental problems including pollution problems were found in several studies. Generally, research is conducted on pre-service teachers, elementary school students, and secondary schools (Celikler & Aksan, 2011; Özsoy & Ahi, 2014; Cetin, 2015; Pinar & Yakisan, 2017; Demirel & Kiroğlu, 2021; Kiryak et al., 2021;). Research from Pınar & Yakışan (2017) tried to find out elementary school students' perceptions of the environment by analyzing students' drawings about the environment and the results showed that most students described that environmental pollution is caused by garbage. There are not many studies involving prospective science teachers including biology students.

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Selçuk & Yilmaz (2017) concluded that prospective science teachers focus on which types of environmental pollution are harmful, what are the consequences or effects of environmental pollution, and how environmental pollution occurs. Meanwhile, Kalayci (2020) research on 33 pre-service science teachers revealed that there were four types of pollution but only three types were drawn by them, namely air, water, and soil pollution. Of the 4 types of pollution, most of them stated that air and water pollution are the most important and dangerous, and the majority of them stated that humans are the cause of environmental pollution.

In this activity, it is crucial for potential teachers to be familiar with environmental issues, particularly pollution. Therefore, before students engage in learning, it is necessary to conduct an examination to reveal their cognitive perceptions in order to ascertain or identify what they already know about a subject. Understanding cognitive perception, which comprises of the experience and knowledge of learners that will enable the reconstruction and processing of information from incoming stimuli, is crucial for understanding how pupils comprehend previously learned concepts. According to Fisher and Kalyuga's theory, which is cited by Nakiboglu (2016), students accumulate their knowledge and store it in long-term memory in a hierarchically ordered format so that it can be represented as a cognitive perception in their memories.

METHOD

Research Design

This research employed the descriptive case study method as one of the qualitative research designs. Case studies are used to analyze a situation, event, process, or action of one or more individuals (Creswell, 2013). The descriptive method examines the status of a group of people, an object, a set of conditions, a system of thought, or an event in the present. This descriptive research aims to make descriptions and images systematically, actually, and accurately about the facts, properties, and relationships between the phenomena being investigated.

Participants

Students who participated in this study were first-year students in the biology education study program at the Faculty of Teacher Training and Education, Tanjungpura University with a total of 29 people consisting of 4 men and 25 women. These students are students who took environmental science courses and would receive topics on pollution.

Data Collection Tools

In this study, the word association test was used to reveal the cognitive structure of prospective biology teachers about the concept of pollution. Word association test allows pre-service teachers to write down which word/phrase first comes to mind. Basol and Balgalmis (2016) stated that the word association test helps to find the cognitive structure of individuals. In this study, the pre-service teachers were given 30 seconds to write down 5 words related to pollution. The open-ended question was given to the pre-service teachers to write a sentence about what pollution is within 1 minute. The pre-service teachers were given 5 minutes to explain the solution to overcome pollution in the form of drawings.

Data Analysis

The data analysis conducted was a descriptive analysis. The descriptive analysis was carried out to see the frequency distribution and average student answers on each research variable. The descriptive analysis aims to present the data clearly according to the findings (Simsek, 2016). The descriptive analysis was performed to measure the cognitive structure of pre-service teachers. First, students' answers were recorded and coded M1, M2, ..., M29 on each word that had associations with questions related to environmental pollution. Then, the data obtained from the word association test were analyzed using content analysis to reveal the words written by the students, the data were then examined and given the same code if they appeared simultaneously (Balci & Simen, 2016). The words written by the students were then categorized. Second, pre-service teachers' answers about what pollution is through open-ended questions were content-analyzed to reveal the sentences written by the students, then they were examined and given the same code if they appeared simultaneously (Balci & Simen, 2016). Third, the drawings made by pre-service teachers to explain the solution to pollution were examined according to visual elements with two categories: 1) the form of the solution, and 2) the surrounding elements, without making psychological interpretations.

FINDINGS

Prospective biology teachers' conceptions of pollution

The words written by pre-service teachers related to pollution based on the word association test are presented in Table 1. The pre-service teachers elicited 30 words related to pollution and there were a total of 113 repetitions grouped into four categories (Table 1).

Table 1: Code/word, frequency, total frequency, and category of pollution concept

Code/Word	Frequency	Total Frequency	Category
Water	3	14	Type of pollution
Soil	2		
Air	7		
Voice	2		
Pesticide	1	61	Pollution Cause
Dangerous substance	2		
Forest fire	2		

Particle	1		
Impurity	1		
Smoke	4		
Dust	3		
Living creature/human	4		
Noisy	4		
Pollutant	6		
Waste	15		
Garbage	13		
Vehicle	1		
Negligence	1		
Flood	3		
Dirty	10	32	Impact of Pollution
Smell	5		
Clogged	1		
Polluted	2		
Disturbed ecosystem	1		
Damaged	5		
Loss	2		
Disease	6		
Throwing away rubbish into the trash can	3	6	Solution to overcome pollution
Greening	3		

Based on Table 1, the words raised by prospective biology teachers can be grouped into four categories, namely types of pollution, causes of pollution, consequences of pollution, and solutions to overcome pollution. 29 prospective teachers who gave vocabulary about the concept of pollution, the category of pollution causes had the highest frequency (f=61), the most frequent vocabulary of prospective teachers were "waste" and "garbage", while the vocabulary that only appeared once in this category were pesticide, particle, impurity, vehicle, and negligence. Prospective teachers had a low cognitive perception of solutions to overcome pollution (f=6) because they only mentioned throwing garbage in its place and greening, none of the prospective teachers mentioned recycling as one of the solutions in overcoming pollution. Meanwhile, the category of consequences of pollution has the second highest frequency after the cause of pollution (f=32) and the category of types of pollution with a frequency of 14. From Table 1, we can also see the concept network of words with 5 or more repetitions as shown in Figure 1.

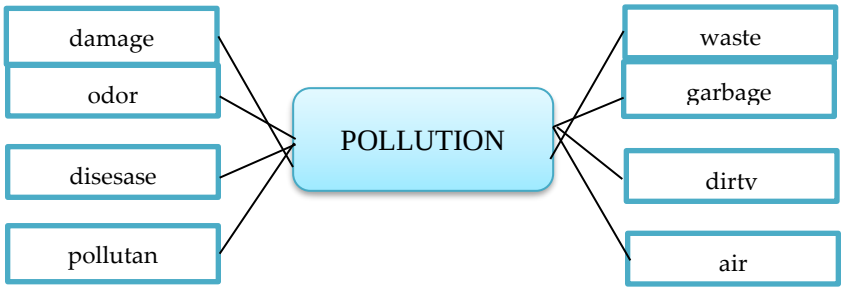

Figure 1: Concept network of words with high repetition frequency

Table 1 also shows that the category with the most frequency revealed by students is the cause of pollution with the word content that often appears is waste and garbage. This is due to many books or reading materials including pictures and videos that explain waste and garbage as causes of pollution. For the category of pollution types, more students wrote air pollution followed by water pollution, soil pollution and sound. This is because the area where students live every year often experiences air pollution due to land burning smoke. The concepts of "dirty", disease", and "odor" were written by many students for the category of the consequences of pollution. Meanwhile, the category that is still less raised by students is in the category of solutions to overcome pollution. Only 6 students came up with words related to this category in the form of throwing garbage in its place and greening, this may be an indication because prospective teachers interact more often with the causes of pollution and more often appear in books and television. Therefore, educators need to prepare strategies to deliver material related to solutions to overcome pollution and encourage prospective teacher students to design or create ideas to overcome pollution.

Opinions of prospective biology teachers about a pollution

The prospective biology teachers were asked to give their opinions about pollution through an open-ended question. Responses from the participants are shown in Table 2.

Table 2: Sentences of prospective biology teachers about pollution

Definition of Pollution	f
The process of entry or inclusion of living things, elements, substances, energy, and other components into the environment that make the environment cannot function as its designation	18
The entry of unwanted substances, components, or living things that harm the system due to human activity or nature	6
The entry of living things, substances, energy, or other components into the environment due to human activities	2
The state of environmental degradation caused by household waste, industry, etc.	1
The disruption of the environment that has a negative impact on the surrounding	1
A situation in which the condition of the environment or place of residence becomes uncomfortable to live in due to several factors	1

Based on Table 2, the prospective biology teachers wrote the most sentences about pollution as stated in Law Number 23 of 1997 concerning Environmental Management. This could be due to the knowledge they have acquired in their previous education. When the participants' responses were examined and linked to the vocabulary that had been written previously, the words "living things", "humans", "disturbed environment", "damaged", and "waste" were also used by them to write their opinions about what pollution is.

The solution to overcome pollution by prospective biology teachers in the form of drawings

The prospective biology teachers were asked to describe ways/solutions to overcoming pollution through drawing. The drawings of 29 prospective biology teachers were examined by categorizing them based on the type/form of the solution and the elements around it (Table 3).

Table 3: Elements/codes, frequencies, and categories of drawings of pollution solutions

Element/Code	Frequency	Category
Go green logo, environmental friendly car, plant in the bank of the road, sidewalk, pedestrian, cyclist and their lane	6	Go green
Trash can, text “Throw garbage in its place”	8	Throw garbage in it place
Trash can with explanation “organic”, “inorganic”, “B3”	2	Sorting garbage
Planting the tree, passage “let’s plant tree”, male and female plant and water a tree	9	Greening
Tree, trash can, passage “let’s plant tree and throw the garbage to its place”	4	Planting tree an throwing rubbish

Based on Table 3, the pre-service teachers drew more about reforestation and disposing of garbage in its place as a solution to overcome pollution as shown in Figure 2 and Figure 3.

Figure 2: Example of student’s drawing (M19)

Throwing garbage in its place (garbage cans) is a solution to overcoming pollution that is simple and can be practiced daily, which is the conclusion raised by students in Figure 2. Meanwhile, in Figure 3, student (M5) drew a woman planting a tree and a boy watering the plants as a solution to overcoming pollution in the form of planting trees or greening.

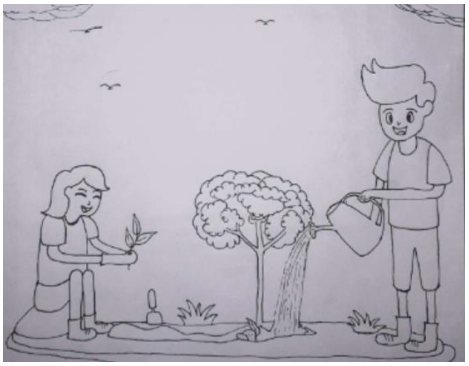

Figure 3: Example of student's drawing (M5)

Another solution raised by the pre-service teachers in overcoming pollution is to dispose of garbage by sorting the types of garbage (Figure 4).

Figure 4: Example of students' drawings (M3 and M17)

Based on Figure 4, the pre-service teachers think it is necessary to provide trash bins based on their types, namely organic, inorganic, and hazardous waste. The segregation of these types of waste certainly facilitates their disposal and recycling, in addition to preventing the accumulation of waste that can lead to air pollution and flooding.

Another drawing that was raised as a solution by pre-service teachers is shown in Figure 5.

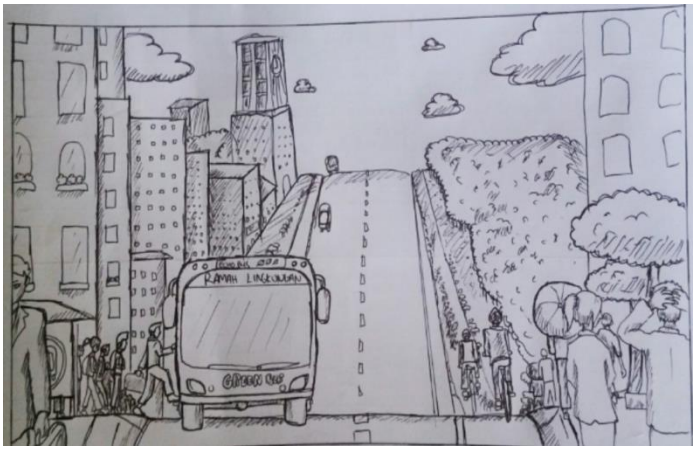

Figure 5: Example of a student's drawing (M22)

Based on Figure 5, environmentally friendly cars, roadside plants, sidewalks, pedestrians, cyclists and their paths are solutions to pollution as a form of going green because they change lifestyles to be more eco-friendly or environmentally friendly. Being more aware of the surrounding environment by changing lifestyles can reduce pollution levels.

Discussion

Cognitive perceptions of prospective biology teachers produced varied answers related to pollution. Answers given by prospective teachers as their cognitive perceptions have been said to be quite good but need to be improved and reinforced on several components. The answers raised by prospective teacher students seem to come from what they received in learning at the previous level and what they remember when the questions are given so that special

strategies are needed from educators so that prospective teacher students do not just remember what they have learned. But they can criticize or convey new ideas related to pollution. As the constructivist theory states that meaningful learning can occur when learners are able to connect new knowledge given with their pre-existing knowledge. Therefore, learning should prioritize the learning process rather than the learning outcome itself by involving complex thinking processes, such as RICOSRE (Yuliskurniawati et al., 2019), GIReSiMCo (Senisum et al., 2022), and think-pair-share-write based on hybrid learning (Siregar et al., 2017), predict-observe-explain based project (POEP) learning (Ilma et al., 2022), and Project Based Learning (Chasanah et al., 2019). Through the word association test, it was revealed that the words that exist in the cognitive structure of pre-service teachers can be grouped into 4 categories, namely the type of pollution, the cause of pollution, the consequences of pollution, and the solution. Based on the data in Table 1, the students were able to mention the types of pollution, namely air, soil, water, and sound pollution. The type of pollution most written by students is air pollution, a similar concept seen in the research of (Yücel & Özkan, 2018). Air pollution is one of the major issues of concern locally, nationally, and internationally because it is a major threat to human health and other living things on earth. Choudhary and Garg (2013) stated that air pollution creates smog and acid rain, causes cancer and respiratory diseases, reduces the atmospheric ozone layer, and contributes to global warming. Smoke and respiratory diseases/disorders are two things that participants in this study always encounter because the Pontianak city area in particular and West Kalimantan province in general have experienced problems due to haze in recent years. This is in line with Arifa (2022), the haze that occurs due to forest fires in Pontianak is very extreme which causes the air quality to be very poor, causing health problems in humans, especially the respiratory system. The experience of the event reminds students of the danger and it provides the information needed thus it appears to be their cognitive perception.

Meanwhile, garbage and waste became the majority of students' answers for causes of pollution even though they also mentioned smoke, dust, vehicles, and forest fires. Uyanik (2017) research explained a similar concept regarding garbage/waste as a source of pollution which had the highest frequency of answers by students. Most of the students who wrote the vocabulary of air pollution, waste, and garbage in this study are similar to the research conducted on medical students who concluded that air pollution, waste, and the reduction of forest areas are 3 very important environmental problems (Özden & Özden, 2015). The students' answers to the consequences of pollution are that the environment becomes dirty and damaged, and it causes disease, this is certainly in line with their answers regarding the causes of pollution. It is also supported by throwing garbage in its place and reforestation as a solution to overcome pollution. The cognitive process experienced by students in understanding information that appears through their senses is perception because they understand and are able to interpret the stimulus that appears and then process it thus it gives rise to meaning about an object. This became one of the answers given by students which were interrelated because the core of cognitive development is the memory where someone who learns always involves memory. Memory allows us to store information received over time.

The pre-service teachers' answers from the results of the word association test continued with the answers they gave through the open-ended question on "What is pollution?". The sentences written by pre-service teachers mostly explained that pollution is the entry of "something" (living things, elements, substances, energy, and other components) such as waste into the environment causing the environment to be disturbed. This finding shows that the sentences written by them are still limited to memorization of the definition of pollution based on Law Number 23 of 1997 concerning Environmental Management. Based on this, it can be seen that students' cognitive perception of what pollution is is still low, students have not been able to write the effects of pollution on the lives of living things clearly and what causes pollution to occur. However, some students wrote that pollution is caused by human activities and nature, while a polluted environment causes the environment to be uncomfortable to live in. Yucel and Ozkan (2016) in their research also found a similar thing, namely that some pre-service teachers did not write the impact of environmental pollution on the lives of living things.

The drawings made by pre-service teachers to describe ways/solutions in overcoming pollution include throwing garbage in its place as well as sorting the garbage based on their types (Figure 1 and Figure 3), doing reforestation as an effort to overcome air pollution (Figure 2), and environmentally friendly movements (Figure 4). This shows how these concepts exist in the cognitive structure of students. The illustrations in the drawings made by students reveal efforts to prevent pollution that dominantly come to their minds or what they can do, namely in terms of preventing or reducing the impact of air pollution. "One of the reasons to prevent air pollution is to use environmentally friendly buses, use bicycles, prepare comfortable and safe sidewalks for pedestrians, plant plants on the side of the highway (M22)". This means that people must change their lifestyles to be more eco-friendly. This research is similar to research conducted by (Palaz & Akbaba, 2018; Kalayci, 2020) that the environmental issue that comes to the minds of students is air pollution. This shows that there are similarities between the issues that exist in the minds of students on topics related to environmental problems and global issues. Therefore, appropriate environmental education should be provided to students to provide insights to address environmental issues such as pollution (Gülüm, 2011).

Drawings can be used to illustrate what is understood without fear and it can be presented in a more detailed way thus it looks clearer. Similar to this study, research by Tarhan and Kizilay (2017) examined cartoon drawings made by students about violence against humans and animals which illustrated environmental issues. Meanwhile, Kalayci (2020) described illustrations made by students related to air, water, and soil pollution. Yazici (2006) revealed that drawings can obtain different perspectives from each student, all of which are effective in increasing individual awareness regarding the topics discussed. Meanwhile, according to Koca et al., (2019), drawings can be used to see the level of student readiness based on their subconscious related to environmental pollution because the drawings are made to bring up cognitive aspects such as symbols and signs.

The results of the word association test were effective enough to determine the information in the minds of prospective biology teachers related to the concept of pollution and became a good predictor of the relationship between concepts in a material or learning topic. The words written by prospective biology teacher students when given a word association test helped them in answering open-ended questions and in expressing them in the form of drawings. This is in line with the research of Uzun et al., (2010); Nakboglu (2016); and Alkan et al., (2021) who concluded that word association tests are useful as an alternative method to bring out conceptual organization in students' knowledge structures, map students' cognitive structures, and means of diagnosis and conceptual transformation strategies.

Conclusion

The environment is inseparable from the emergence of problems, human activities in the environment are the biggest contributor to the emergence of pollution. Based on the results of the study, it can be concluded that first, students have varied vocabulary related to pollution, namely vocabulary related to types of pollution, causes of pollution, consequences of pollution, and solutions for pollution. Second, according to the majority of students, pollution is the entry of "something" (living things, elements, substances, energy, and other components) such as waste into the environment thus the environment becomes disturbed. Third, the efforts to prevent pollution that most students make in the form of drawings are solutions to air pollution such as reforestation and environmentally friendly transportation.

Fourth, the cognitive perception of prospective biology teachers is quite good but needs to be improved and strengthened.

Suggestion

For future research, it is suggested to add semi-structured interviews individually or through forum group discussions to obtain deeper thoughts and richer comments on participants' cognitive perceptions. Similar research can be conducted on prospective teachers from other fields of science as well as from prospective social studies teachers because the topic is related to the environment. In addition, it is necessary to compare the cognitive perceptions of students at the elementary, secondary, and higher education levels to get a complete overview because the level of maturity in terms of age can affect cognitive development.

Limitation

This research has limitations, especially on the part subject involving prospective biology teacher students and a small number of participants.

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