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Teaching Strategies for Microplastic Material in Science Learning: Literature Review

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Abstract: Waste is one of the polemic problems that occurs in Indonesia. Almost every region has savings in the form of waste in large amounts and is spread throughout Indonesia. Not a few people do not care about the use of plastic waste which can cause environmental pollution. This study highlights the teaching of microplastic material, a new global environmental problem, in science learning. The novelty lies in the emphasis on topics that are relevant to current environmental conditions and offer innovative learning strategies, such as project-based methods, experiments, and digital technology, to improve students' understanding. This research aims to analyze science learning strategies in integration with microplastics. The method used in this research is a literature review using the PRISMA approach. The data source was taken from Sinta 1-3 via the Google search engine over the last 6 years. The results of the review found that the learning model most frequently used as Problem Based Learning (PBL), then the second most frequently used was the Guided Inquiry model. These two learning models are often used because they are most relevant to the nature and complexity of environmental problems, while the learning model that is rarely used is the Discovery Learning model because this model gives students the freedom to find information independently so that if students are not guided it will cause unnecessary misunderstandings. adequate regarding environmental pollution problems.

Keywords: Learning steps; Microplastic

Introduction

Waste is one of the polemic problems that occurs in the world. Plastic waste production increases every year because the world population increases (Prasetiawan, 2018). Every region in Indonesia also has a large amount of waste savings, even spread throughout Indonesia. Based on a report by the Sekjen KEMENKEU (2019), Indonesia is the second largest contributor of plastic waste after China with the production of 9.85 billion pieces of plastic waste annually, while the contribution of plastic waste in Indonesian waters according to Qodriyatun (2018) was 187.2 million tons per year. Based on research by Wahyudi et al. (2020) stated that China implemented a policy of banning waste imports in 2013, after which Indonesia opened the gates for import activities of more than 40% of plastic waste such as sachets, pouches, bags, and films since 2018 (Akenji et al., 2019). According to research by Lebreton et al. (2017), there were 122 rivers in the world (around 490%) that contributed plastic waste to the waters, then 103 rivers were located in Asia, eight in Africa, eight in South America and Central America, and one in Europe. It is not surprising that waste in the ocean is dominated by plastic waste (90%), coastal areas contribute around 32–90%, sea surface water accounts for 86%, and the seabed accounts for 47–85% (Suryono, 2019).

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Based on this, plastic waste in waters will have a serious impact on the environment and aquatic biota. Water bodies contaminated with plastic waste can be toxic and dangerous for marine animals, damage marine ecosystems, and threaten human health if they consume fish and seafood contaminated with plastic. Therefore, efforts to overcome the problem of plastic waste can involve encouraging the community to reduce the use of single-use plastics, good waste management, as well as education and public awareness about the impact of plastic waste in coastal areas.

Microplastics can circulate in aquatic environments, such as rivers, lakes, oceans, and even soil. Microplastics can be a serious environmental problem because they do not break down easily and can persist in the environment for several years. Microplastic particles can cause problems for marine life and ecosystems because they can be consumed by marine biota, thereby spreading into the food chain. According to Wright et al. (2013), biota contaminated with plastic waste can cause damage to the digestive tract, reduce growth rates, affect reproduction, and be exposed to greater exposure to toxic plastic additives.

The use of plastic in various consumer and industrial products causes an increase in microplastic problems. The government has made various efforts to reduce the use of single-use plastics, strengthen plastic waste management regulations, and develop more environmentally friendly plastic management methods (Chotimah et al., 2021).

Microplastic pollution is a serious problem because it can damage the ecosystem and endanger living things, including humans. In science learning in junior high schools, it is important to teach students about the impact of microplastics on the environment so that they care more and understand how to reduce plastic use and maintain environmental cleanliness. Students' interest in reading environmental literature can be piqued and their concern for the environment can be reinforced when they are provided with real-world examples and worksheets to consider environmental contamination (Amala et al., 2023).

Based on the above, it shows that public awareness of plastic waste is still low due to a lack of adequate education about the negative impacts of excessive use of plastic and how to manage waste properly, so there needs to be a joint effort from the government, educational institutions, companies, and the community. Effective education, environmental awareness campaigns, and policy changes can help change people's habits regarding this issue. This study discusses the teaching of microplastic material, a new environmental problem, in science learning. The novelty lies in the relevance of the topic to current environmental conditions, as well as the use of innovative learning strategies such as project-based methods, experiments, and digital technology. This study also integrates environmental awareness into science learning, helping students understand the impact of microplastics on ecosystems and health. In addition, this study develops a curriculum or teaching materials about microplastics that have not been widely applied in science teaching. Therefore, this research aims to analyze learning strategies by integrating microplastics into science learning so that students gain broad insight and can grow and increase their awareness of the impact of using plastic waste.

Method

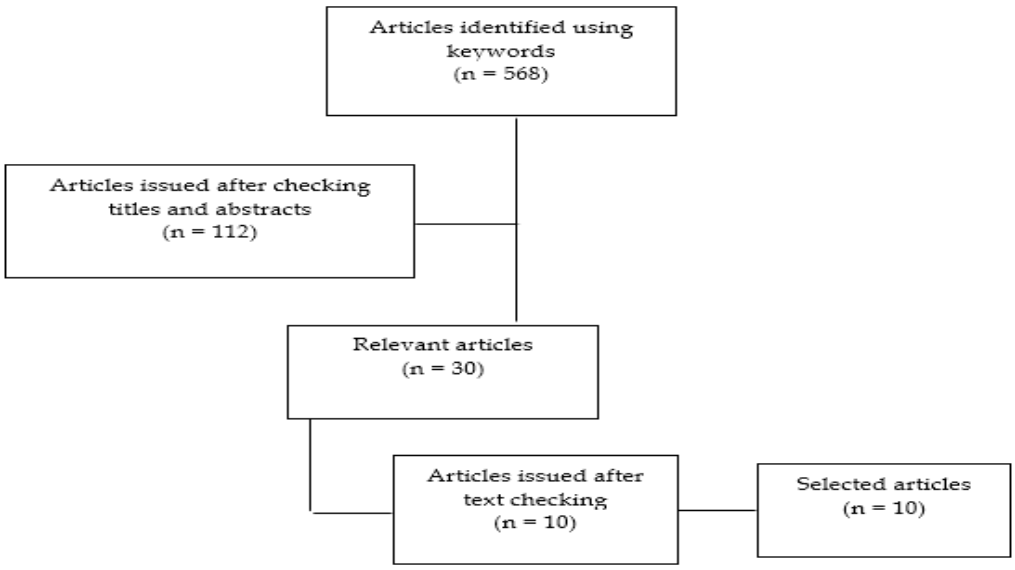


Figure 1. Article selection flow

The method used in this research is the literature review method. The stages of this research can be seen in Figure 1 using the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) approach. The criteria for this research use the inclusion of articles and journals that are relevant to the research title, then analysis of the material taught in the form of microplastics (the understanding and process of spreading microplastics and the impact of microplastics on the surrounding environment) which is included in environmental pollution material in class VII SMP, learning models, learning methods, and learning approaches. The journals cited are Sinta 1-3 indexed journals published within the last 6 years.

Based on the results of the literature review that has been carried out, the aim is to describe and relate microplastics to science learning. 568 articles on environmental pollution were found, and the titles and abstracts of articles that were relevant to the issue were 112 articles. These articles were identified so that there were 30 published articles and the 10 most relevant articles based on the inclusion criteria.

Result and Discussion

Based on the results of the literature review that has been carried out, the aim is to describe and relate microplastics to science learning. 568 articles on environmental pollution were found, and the titles and abstracts of articles that were relevant to the issue were 112 articles. These articles were identified so that there were 30 published articles and the 10 most relevant articles based on the inclusion criteria.

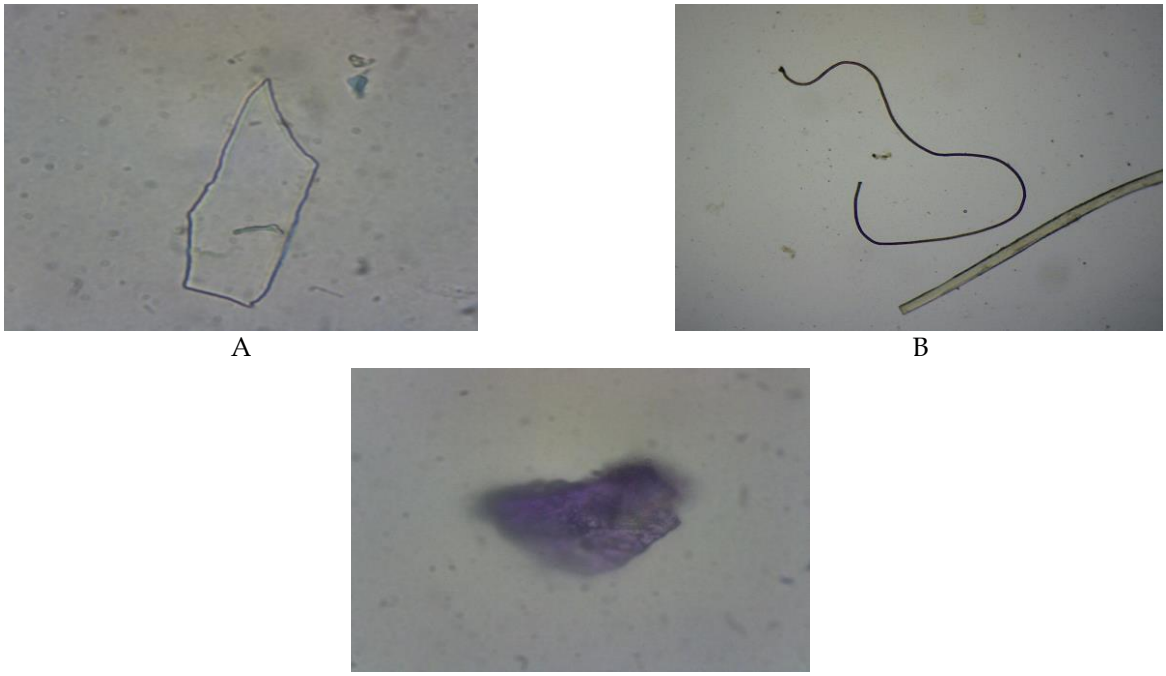
Based on the results of the literature review, those that meet the feasibility of a systematic review in the last 6 years are the Problem-Based Learning (PBL) learning model and the Guided Inquiry learning model. Apart from that, experimental methods with a scientific approach are also often used in the learning process. This data can be seen in Table 1. Microplastics are plastic particles that are less than 5 millimeters (mm) or 0.2 inches in size. Microplastics come from various sources, larger pieces of plastic can also be produced in microscopic form, such as those used in care products such as facial cleansers, or in industry and manufacturing processes.

Based on their origin, microplastics are divided into two types, namely primary microplastics and secondary microplastics (Septian et al., 2018). Primary microplastics are microplastics that are small (micro) when in water, such as microbeads in cosmetic waste (Zhang et al., 2017). Secondary microplastics are large plastic waste that is found in water and undergoes a degradation process so that it turns into smaller fragments. It is estimated that microplastic fibers in water reach 4 billion fibers per square kilometer (Septian et al., 2018).

The process of microplastics comes from plastic waste which is decomposed into small pieces. Plastic waste that is thrown anywhere will enter rivers, then be carried by currents to the ocean and will spread throughout the world (Zhang et al., 2017). Based on research by Hardesty et al. (2017), the spread of plastic throughout the world is caused by oceanographic processes that occur, especially ocean currents, tides, and other things. Plastic collected in the sea experiences photodegradation, oxidation, and mechanical abrasion to form plastic particles. Microplastics that are spread into the surrounding environment, especially in water, can enter the bodies of organisms because their shape resembles food (Nugroho et al., 2018). The forms of microplastics can be seen in Figure 2.

Microplastics come in the form of fragments, fibers, and films (Ayuningtyas et al., 2019). Microplastics in the form of fragments come from community waste such as rice wrappers, styrofoam, plastic bottles, and ready-to-eat food packaging which are degraded into small fragments (Dewi et al., 2015). Microplastics in the form of fibers are usually found at the edge of the water due to community activities such as fishermen or anglers. Fiber can come from clothing manufacturing waste, rope, and plastic sacks (Nor & Obbard, 2014). According to Yudhantari et al. (2019), fiber is long and thin in shape, so fiber is often found on the surface of water and is dangerous for biota because it can block the passage of food into the digestive tract due to lumps. Fiber has long size and is shaped like blue, red, and green fibers, while black fiber 11 comes from semi-synthetic rayon which is made from cellulose (Lusher et al., 2013). According to Septian et al. (2018), film is a microplastic that comes from plastic bags or plastic packaging, so it has a lower density than fragments and fibers. According to Yudhantari et al. (2019), the film has an erratic shape and is thin and transparent in color.

The color of microplastics comes from household waste which produces blue, red, and green colors (Lusher et al., 2013). According to Suwartiningsih et al. (2020), blue microplastics indicate a similarity to the color of natural foods such as zoobenthos. Research conducted by Hiwari et al. (2019) found that microplastics were predominantly black, whereas dark colored microplastics indicated that the microplastics had not undergone color breakdown, and the more the dark color faded, it indicated the length of time the microplastics had been degraded by ultraviolet light.



A B C

Figure 2. Microplastic forms: film (A), fiber (B), fragment (C)

Table 1. Summary data description

Author and Title	Learning Model	Learning Method	Approach	Result
Hastuti et al. (2018). The Influence of Inquiry-Based Science Issues Learning on Practical Skills of Junior High School Students in Environmental Pollution Topic	Inquiry	Experiment	Scientific	The results of the significance test are 0.000 < 0.005, meaning that inquiry affects improving the practical skills of Paliyan 1 Middle School students. Inquiry syntax is more effectively used in science learning compared to the scientific approach
Novita et al. (2022). E-modules Through Flipped Classroom and PBL Models on Environmental Pollution Material to Increase Problem-Solving Ability	PBL	Flipped Classroom	Contextual	Smartphone-based e-modules can improve problem-solving abilities and SMA 2 Bantul students have maximum interest in independent learning and achieve the desired competencies
(Rubini et al. (2017). Improving Students' Scientific Literacy on Environmental Pollution Topics Through Laboratory-Based Discovery Learning	Discovery Learning	Experiment	Guided Inquiry	The N-Gain value of 57.84% has increased compared to the control class. Activities carried out in the laboratory are very effective because they can increase students' scientific literacy
Fatimahwati et al. (2021). Application of Problem Based Learning Model with SETS Vision to Increase Students' Learning Motivation on Environmental Pollution Material	PBL with SETS vision	Experiment	Scientific	The results of the significance value between the experimental class and the control class are 0.000 < 0.05, which means that the implementation of PBL with a SETS vision can increase the learning motivation of class VII students at SMPN 8 Banda Aceh
Amalya et al. (2021). Implementation of the Problem Base Learning Model combined with E-STEM Based Student Worksheets on Learning Outcomes and Self Efficacy on Environmental Pollution Materials	PBL	Experiment	E-STEM	The Independent Sample T-test result is 0.05, which means that the PBL model combined with E-STEM-based LKS can identify, find solutions, and overcome water, air, and land pollution problems

Author and Title	Learning Model	Learning Method	Approach	Result
Permata et al. (2022). The Effect of the Problem Based Learning and Double Loop Problem Solving Learning Models on Problem Solving Ability in Term of Creative Thinking on Environmental Pollution Material	PBL- Double Loop Problem Solving (DLPS)	PjBL	Scientific	The results of the hypothesis test obtained significance values of 0.0816 and 0.05. This means that there is no interaction between the PBL and DLPS learning models and creative thinking on the problem-solving abilities of class VII students at SMPN 1 Sukodadi and SMPN 1 Sekaran
Putri & Ngabekti et al. (2021). The Development of Green Science Board Game (Greecebome) Media on Environmental Pollution toward Student Interest in Learning	Greecebome (Green Science Board Game)	Game-Based Learning	Contextual	Media Greecebome has an average percentage of 94%. This means that this media is interesting to use during learning activities to increase students' understanding of pollution material. The percentage of science teachers was 96.88% who indicated that the media was very suitable and supported learning activities
Nurmilla et al. (2018). The Effectiveness of Guided Inquiry Learning with JAS Approach on the Learning Result of Environmental Pollution Material	Guided Inquiry	Exploring Nature Environment Exploration (JAS)	Natural	Guided inquiry learning has a positive impact on students to train themselves to work together in groups
Nazliah & Saragih (2019). The Effect of Inquiry Based Learning Model on Students' Learning Outcome of the Environmental Pollution Topic at Senior High School Negeri 1 Kualah Hulu	Guided Inquiry and Modified Free Inquiry	Experiment	Conventional	The analysis results obtained were P = 0.002 < 0.05, which means there is a significant influence between the guided inquiry, modified free inquiry, and conventional learning models. Student learning outcomes using guided inquiry are more effective compared to the two models
Citradevi et al. (2017). The Effectiveness of Project Based Learning (PjBL) Worksheet to Improve Science Process Skill for Seven Graders of Junior High School in the Topic of Environmental Pollution	PjBL	Experiment	Scientific	The results of the significance test are 4.60 > 1.67 (tcount > ttable), meaning that there is a significant difference in improvement. Project-based worksheets are effective in improving students' cognitive results on the topic of environmental pollution

Table 2. Learning steps (syntax) Problem Based Learning (PBL)

Syntax	Teacher Activities	Student Activities
Problem orientation	Teachers convey the most urgent environmental problems through pictures and videos.	Students observe and understand the problems presented in the pictures and videos.
Organizing students to study	The teacher divides the groups and ensures that each group understands their respective assignments.	Students discuss and divide tasks to find the tools and materials needed for the practicum.
Practical guidance	The teacher monitors student involvement during the practicum process (data collection).	Students carry out practical work (searching for data) by dissecting the fish's digestive tract and then extracting it using 10% KOH to see the characteristics of microplastics.
Presenting practical results	The teacher monitors discussions and guides the preparation of practical reports for presentation.	Students conduct discussions based on the results obtained during the practicum.
Analyze and evaluate the problem-solving process	The teacher guides the presentation and encourages groups to provide input to other groups. The teacher concludes the material with the students.	Each group makes a presentation, and the other groups respond. The activity continues by making conclusions (summaries) according to those obtained from other groups.

Based on the results of the review in Table 1, the Problem-Based Learning (PBL) learning model and the Guided Inquiry model are the learning models most often used in science learning with a focus on environmental pollution because these learning models are very relevant. with the nature and complexity of environmental problems. The PBL model allows students to learn through solving concrete problems related to environmental pollution. By starting to recognize the urgency of real problems, students can see the direct impact of environmental pollution and develop a deeper understanding of these problems.

Apart from that, the advantage of the PBL model in science learning is that it can develop students' analytical and critical thinking skills in solving complex problems, identifying root causes, and designing appropriate solutions. The PBL model allows students to be more active in learning, both individually and in groups during the learning process. PBL encourages students to ask questions, search for evidence, and consider various solutions to solving complex environmental problems.

The advantage of the Guided inquiry model is that it allows students to be active in their discoveries. Students are invited to ask questions, identify problems, and find solutions. This allows students to develop a deep and active understanding of environmental pollution problems. The Guided Inquiry model also encourages students to think critically and work in groups in discussing, evaluating evidence, identifying causal factors, and formulating reasonable solutions, so that students understand and can solve environmental pollution problems together. In addition, in the Guided Inquiry model students are invited to integrate various scientific concepts, such as chemistry, biology, physics, and environmental science, when they explore environmental pollution problems. This helps students understand the relationship between concepts and their application in real contexts.

The learning model that is least often used is discovery learning, because students learn through independent exploration and discovery. The discovery learning model gives students the freedom to discover concepts and information on their own. However, in the context of environmental pollution, the problem is often very complex and has potentially serious consequences. Relying on students to discover knowledge without careful guidance or control can be risky, as incorrect information or inadequate understanding of environmental pollution issues can result in unwise actions. In addition, discovery learning requires high levels of guidance to ensure students gain an accurate and relevant understanding of environmental pollution because this material involves various scientific concepts such as chemistry, biology, physics, and environmental science so the discovery learning model is less effective in helping students understand and integrate these concepts without a strong guide and structure.

Based on the discussion above, there are 2 learning models most often used in delivering environmental pollution material, namely Problem-Based Learning (PBL) and Guided Inquiry. The two learning models have different syntax, so there are several recommendations for learning strategies in conveying microplastic material, both from teacher activities and student activities which can be seen in Table 2 and 3.

Table 3. Learning steps (syntax) Guided Inquiry

Syntax	Teacher Activities	Student Activities
Identification of problems	Teachers convey the most urgent environmental problems through pictures and videos.	Students observe and understand the problems presented in the pictures and videos.
Asking question	The teacher guides students to ask questions based on the events and problems presented.	Students analyze questions based on the concepts presented.
Plan an investigation	The teacher divides the groups, ensures that each group understands their respective tasks, and develops appropriate work procedures.	Students discuss and divide tasks to find the tools and materials needed in the practicum.
Collect data and conduct investigations	The teacher guides and monitors student involvement during the practicum process (data collection).	Students carry out practical work (searching for data) by dissecting the fish's digestive tract and then extracting it using 10% KOH to see the characteristics (color and shape) of microplastics.
Analyze data	Teachers help students analyze data and monitor discussions in making practical reports for presentation.	Students conduct discussions based on the results obtained during the practicum.
Conclude and communicate the results	The teacher guides the presentation and encourages groups to provide input to other groups. The teacher concludes the material with the students.	Each group makes a presentation, and the other groups respond. The activity continues by making conclusions (summaries) according to those obtained from other groups.

Conclusion

In Indonesia, plastic waste is a significant issue. The use of plastic garbage can pollute the environment, but many people don't care. Microplastics are one of the emerging environmental challenges that scientific education needs to introduce. Since this subject is highly pertinent to the state of the environment today, students must be taught it using an innovative approach that makes use of digital technologies, project-based learning, or experimentation. Additionally, by incorporating environmental consciousness into science education, this study aids students in comprehending how microplastics affect ecosystems and human health. Furthermore, this work creates a curriculum or instructional materials on microplastics that haven't been used extensively in scientific classes. Based on this, the Problem-Based Learning (PBL) and Guided Inquiry learning models are more effective in science learning compared to the Discovery Learning model. Both learning models emphasize students in investigating questions or problems that are relevant and significant in real life, encouraging the development of collaboration skills, problem solving, communication, creativity, and other research skills such as analyzing and synthesizing information.

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Conflicts of Interest
The authors declare no conflict of interest.

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