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Problem Based Learning Model Learning Devices For Plastic Waste Management Material Into Hydroponic Installations To Improve Creative Thinking Skills

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Abstract

Creative thinking skills are one of the 21st century skills that must be possessed by students. This skill is related to the ability to create and develop ideas and alternative solutions to various problems. With creative thinking skills, it is hoped that students will be able to develop and survive in today's increasingly competitive era, by utilizing every available opportunity. The researcher aims to determine the effectiveness of learning devices with a problem-based learning model for plastic waste management material to improve students' creative thinking skills. The research method used is 4D. (Define, Design, Development, Disseminate) with 30 grade IX students of SMPN 22 Surabaya as subjects. The results of the study showed a significance value of 0.000 where 0.000 <0.05 so that there is a positive relationship between learning devices and students' creative thinking skills. The average N-Gain score is 0.6 with a moderate category. So it can be concluded that the problem-based learning model learning device is effective in improving students' creative thinking skills.

Keywords: Creative thinking, Effectiveness, Problem based learning.

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INTRODUCTION

Education in the 21st century is a challenge. The world of education has a significant responsibility to address these challenges. To address these challenges, the Indonesian Ministry of Education and Culture has oriented its education concept towards 21st Century Skills (Fadiyah Andirasdini & Fuadiyah, 2024).

The skills that must be present in 21st century learning are not limited to reading and memorizing abilities as in most schools in Indonesia. 21st century skills that must be possessed by the younger generation are critical thinking, creative thinking and the ability to solve problems in everyday life. 21st century life skills are 4C skills (Bagassi & Macchi, 2020). 4C is very important because this activity allows students to work in groups, solve certain problems, increase tolerance for differences between peers, and think critically and creatively to solve problems related to solving various things in life (Asrul et al., 2018). These 21st century skills are in accordance with Law No. 20 of 2003 concerning the objectives of national education, namely to develop abilities and shape the character and civilization of a dignified nation in order to educate the life of the nation. The learning implementation process should be able to encourage students as individuals and citizens who are faithful, productive, creative, innovative and able to contribute to the life of society, nation, state, and world civilization (Haniah et al., 2020).

Creative thinking skills are one of the 21st century skills that students must have. These skills are related to the ability to create and develop ideas and alternative solutions to various problems. With creative thinking skills, it is hoped that students will be able to develop and survive in today's increasingly competitive era, by taking advantage of every opportunity available. Creative thinking skills have four characteristics, namely: (1) fluency thinking skills , which are characterized by generating many ideas, answers, problem solving, questions, providing many ways or suggestions; (2) flexibility thinking skills , which are characterized by producing varied ideas, answers or questions, being able to see a problem from different perspectives, looking for many alternative solutions, being able to change the way of approaching or thinking; (3) originality thinking skills : students are able to produce new and unique expressions, think of unusual ways to solve problems; (4) elaboration skills : students are able to develop an idea or product, detail a situation so that it becomes more interesting (Iqbal et al., 2024).

Creative thinking skills are essential to face future life challenges. Therefore, the Indonesian government has incorporated creative thinking skills into the curriculum. This is discussed in Permendikbud Number 20 of 2020 concerning the Strategic Plan of the Ministry of Education and Culture (RSPK) (Corebima et al., 2017). The Pancasila Student Profile is one of the

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visions and missions of the Ministry of Education and Culture, which was initiated to perfect character education. The Pancasila Student Profile, formulated in Permendikbud Number 22 of 2020, consists of six dimensions: (1) Faithful, Devout to God Almighty, and Noble Morals, (2) Independent, (3) Mutual Cooperation, (4) Global Diversity, (5) Critical Reasoning, and (6) Creative (Maskur et al., 2020).

Science learning can be one way to develop the profile of Pancasila students. In learning activities, students are invited to learn about God's creations, thereby increasing their sense of gratitude and devotion to God Almighty, as a form of implementing the dimensions of Faith, Devotion to God Almighty, and Noble Morals. Furthermore, science learning is expected to facilitate students to be independent, creative, and able to collaborate with others. Furthermore, students can explore Indonesia's potential and identify existing problems around them from a global perspective (Fatah et al., 2016).

Problem-Based Learning (PBL) model is a student-centered learning model that presents real-life problems and encourages students to solve them (Hadi et al., 2022). This problem-based learning model encourages students to actively participate in solving the problems presented, thereby developing their creative thinking skills (Warodiah et al., 2021).

Based on observations and interviews conducted with science teachers and students at SMPN 22 Surabaya, it was discovered that most of the teaching conducted by teachers is still not student-centered. Furthermore, the learning conducted does not teach students creative thinking skills (Sudarmin et al., 2020). The method mostly used by teachers is the lecture method. This method was chosen due to teachers' limited time to prepare learning materials due to the busy teaching schedule every day. SMPN 22 Surabaya is an Adiwiyata school that in its daily life has an environmental culture. Therefore, many authentic problems can be applied in science learning (Suherman & Vidákovich, 2022).

To overcome this problem, researchers aim to determine the effectiveness of learning devices with a problem-based learning model for plastic waste management material to improve students' creative thinking skills.

PROBLEM-BASED LEARNING LEARNING DEVICES AND CREATIVE THINKING SKILL

Problem-Based Learning (PBL) is a student-centered instructional model that emphasizes authentic problem-solving, inquiry, collaboration, and reflective learning processes. In science education, PBL encourages students to actively construct knowledge through contextual problems closely related to daily life and environmental issues (Hmelo-Silver, 2004). This learning approach

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is considered effective in developing higher-order thinking skills because students are required to identify problems, generate alternative ideas, evaluate evidence, and formulate solutions systematically (Savery, 2015). Creative thinking skills, which include fluency, flexibility, originality, and elaboration, are important competencies developed through PBL activities because students engage in exploration and innovation during learning processes (Nulhakim et al., 2020; Leasa, 2023).

The effectiveness of PBL implementation is strongly influenced by the quality of learning devices used during instruction. Learning devices such as lesson plans, student worksheets, teaching materials, and assessment instruments designed according to PBL syntax can support meaningful learning and improve students' active participation (Arends, 2012). Previous studies reported that PBL-based learning devices significantly improved creative thinking skills, scientific literacy, and environmental awareness among junior high school students (Nurwidodo et al., 2024; Rahmawati & Suprapto, 2023). In addition, integrating contextual environmental issues into PBL activities can stimulate students to produce innovative ideas and practical solutions to real-world problems (Bybee, 2019). These findings indicate that the development of systematic and contextual PBL learning devices is important to facilitate creative thinking development in science learning.

PLASTIC WASTE MANAGEMENT THROUGH HYDROPONIC INSTALLATIONS IN SCIENCE LEARNING

Plastic waste has become one of the most significant environmental challenges due to its increasing accumulation and long decomposition process. Educational institutions have an important role in developing students' environmental awareness and sustainable behavior through contextual science learning (Yue et al., 2023). Integrating plastic waste management into science education enables students to understand environmental problems while simultaneously developing problem-solving and innovation skills. One contextual learning activity that can be implemented is the use of plastic waste materials, such as used bottles and containers, as hydroponic installations. Through this activity, students can learn about recycling, sustainable agriculture, and environmental conservation in an integrated manner (Hapipah et al., 2024).

Hydroponic-based environmental learning is also considered effective in improving creative thinking skills because students are directly involved in designing, modifying, and evaluating planting systems using recycled materials (Diawati, 2022). Previous studies found that project-based and problem-based environmental learning activities improved students' creativity, collaboration, and scientific understanding in science learning contexts (Fitriyah et al., 2022;

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Rahmawati & Suprapto, 2023). However, most previous studies focused on instructional implementation rather than on the systematic development of integrated learning devices. Research specifically addressing the development of PBL learning devices for plastic waste management integrated with hydroponic installations at the junior high school level remains limited. Therefore, this study is important to develop valid, practical, and effective learning devices that can improve students' creative thinking skills and environmental problem-solving abilities.

METHODS

Social Learning Theory asserts that social behavior is learned by observing the behaviors of others. According to Bandura (1977), the theory of social learning suggests that attitudes and behavior of others affect folk's behavior and attitudes. In other words, by perceiving how someone else complies, people learn appropriate and regulatory behavior. In addition, such an apprentice allows people to be self-assured and clarifies one's behavioral and inspirational trends (Walumbwa et al., 2011). Ideas of Social Learning Theory were combined by Burgess and Akers (1996) from adaptive behavioral psychology with Sutherland's (1947) nine core values of deviant behavior. Nowadays, this theory is widely accepted as one of the most influential models of deviant behavior.

This research is a type of development research. This development research uses the 4D model (*Define, Design, Development, Disseminate*) adapted from Thiagarajan, et al. (1974). This research uses. This research was conducted at SMPN 22 Surabaya in the odd semester of the 2025/2026 academic year. The subjects of this research were 30 ninth grade students (Yaniawati et al., 2020).

This study aims to determine the effectiveness of *problem-based learning* model learning tools in improving students' creative thinking skills (Herutomo & Masrianingsih, 2019). The effectiveness of this learning tool is reviewed by analyzing students' creative thinking abilities (Suryana & Seruni, 2019). The analysis of students' creative thinking abilities was analyzed using a paired *t-test* using SPSS and an *N-Gain test* using the following formula:

$$< g >= \frac{skor\ pretest - skor\ posttest}{skor\ maksimum - skor\ pretest}$$

N-Gain calculation obtained is then translated using the following categories:

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Table 1. Interpretation of the *N-Gain Index*

***N-Gain* Value**	**Category**
0.7 < g >1.0	Tall
0.3 ≤ g > 0.7	Currently
0.0 ≤ g > 0.3	Low

(Sundayana, 2015)

The average N-Gain score is then converted into a percentage and categorized based on the following interpretation (Rambe et al., 2022):

Table 2. Interpretation of the average percentage of N-Gain scores

***N-Gain* Value**	**Category**
<40	Ineffective
40 - 55	Less effective
56 - 75	Quite effective
> 75	Effective

(Solikha, 2020).

RESULT AND DISCUSSION

This study uses a 4D research model that has the stages of *Define, Design, Development,* and *Disseminate* (Sayekti, 2020). In the *Define stage* , several analyses are carried out before creating learning tools (Prayogi & Asy'ari, 2021). The analyses carried out include curriculum analysis, student analysis, and material analysis. SMPN 22 Surabaya has been using the independent curriculum since the 2022/2023 academic year (Franita et al., 2020). Therefore, the learning emphasizes the application of the Pamcasila student profile, one of which is creativity (Azizah et al., 2022). The appropriate learning outcomes for teaching creative thinking skills are designing efforts to prevent and overcome pollution and climate change. The selection of CP is adjusted to the *problem-based learning model* . In addition, SMPN 22 Surabaya is an Adiwiyara school so that many authentic problems can be discussed as learning materials. The material to be studied is "Waste Management" which is a sub-material of "Environmental Issues". This CP is taught to grade IX who have received prerequisite material on the Interaction of Living Things and Their Environment in grade VII. Therefore, based on the analysis carried out, the objective of this learning is for students to be able to improve their creative thinking skills through learning *the problem-based learning model* through the material of Plastic Waste Management.

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Students received a pretest *before* participating in the learning using the developed learning tools (Ng et al., 2016). This was done to measure their initial creative thinking abilities. Afterward, students participated in learning using the *problem-based learning model* . The *pretest* and *posttest* consisted of four essay questions, each representing an indicator of creative thinking. The tools used included modules, teaching materials, and student worksheets (LKPD). After participating in the learning, students' abilities were measured again through *a posttest*(Guntur et al., 2020) .

The results of the pretest and posttest conducted by students were then analyzed using *the One Sample t-Test* using SPSS version 26 and the following results were obtained:

Table 3. Results of *One Sample t-Test* of Creative Thinking Skills

Group	Mark (Mean ± SD)	95% Confidence Interval		P - Value
		Lower Limit	Upper Limit	
Pretest	47,666 ± 7,738	44,777	50,556	0.000
Posttest	80,166 ± 7,931	77,205	83,128	

Based on the results of the significance test for creative thinking skills, a significant difference was found in student scores with a sig value <0.05. These results indicate that the learning device with the developed *problem-based learning module* has a positive effect on improving creative thinking skills in each indicator (Koto et al., 2021).

In addition to the t-test to determine the effectiveness of this learning device, an *N-Gain test was conducted* and the following results were obtained:

Table 4. Results of the *N-Gain Test* of Creative Thinking Skills

Indicator	*N-Gain* Score	Category
Fluency	0.6	Currently
Flexibility	0.6	Currently
Originality	0.5	Currently

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Elaboration	0.7	Tall
Average	**0.6**	**Currently**

Based on Table 4, it is known that students' creative thinking ability obtained an *N-Gain score* of 0.6 which is in the medium category. The table also shows the *N-Gain score value* for each indicator of students' creative thinking ability. The *fluency indicator* (fluent thinking) is in the medium category, the *flexibility indicator* (flexible thinking) is at a medium level, *originality (original thinking) is at a low level, and the elaboration* indicator is at a high level (Nasution, 2021).

Table 5. Percentage of students' creative thinking skills with the *N-Gain test*

Number of Students	N-Gain Value	Presentation	Category
15	0.7 < g >1.0	50%	Tall
15	0.3 ≤ g > 0.7	50%	Currently
0	0.0 ≤ g > 0.3	0	Low

There are 30 students who participated in learning using this *problem-based learning model learning device* . Based on table 5, it is known that there are 50% of students who are in the high category with a range of *N-Gain values* of 0.7 < g > 1 and there are 50% of students who are in the medium category with a range of *N-Gain values* of 0.3 ≤ g > 0.7. From the table (Yustina et al., 2020). This shows that students' creative thinking skills are in the medium and high categories (Verawati et al., 2023).

Based on the average *N-Gain score* in Table 4 of 0.6, converted to a percentage of 60%, this result indicates that the *problem-based learning model* is quite effective in improving students' creative thinking skills.

These results are in line with Imaroh's research (Khoiriyah & Husamah, 2018)which shows a significant relationship between students' creative thinking abilities and the application of problem-based learning models in junior high school science learning, with a significance value of 0.000 where 0.000 <0.05 and a correlation coefficient of 0.719, thus indicating a positive and strong relationship direction. Other studies also explain that this problem-based learning model has a positive influence on improving students' creative thinking skills. The problem-based learning model encourages students to be actively involved in solving the problems given, so that they can train their creative thinking abilities, such as fluent thinking, flexible thinking, original

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thinking, and elaborative thinking (Fadiyah Andirasdini & Fuadiyah, 2024).

The findings of this study indicate that the developed Problem-Based Learning (PBL) learning devices effectively improved students' creative thinking skills in plastic waste management learning integrated with hydroponic installations. The significant difference between pretest and posttest scores demonstrates that the implementation of PBL-based learning activities positively influenced students' ability to generate ideas, analyze problems, and propose innovative solutions related to environmental issues. The average posttest score was higher than the pretest score, and the significance value was below 0.05, indicating that the developed learning devices had a meaningful impact on students' creative thinking skills. These results support previous studies stating that PBL creates active and contextual learning environments that encourage students to think critically and creatively when solving real-life problems (Hmelo-Silver, 2004; Savery, 2015).

The N-Gain test results also showed that students' creative thinking skills improved in the medium category, with elaboration achieving the highest improvement among the four indicators of creative thinking. This finding indicates that students were able to develop and explain ideas in greater detail during learning activities involving hydroponic design and plastic waste utilization. The contextual nature of hydroponic projects allowed students to engage directly in experimentation and problem-solving processes, which stimulated creative idea development (Tuni'mah, et al., 2025). This finding is consistent with previous research showing that environmental project-based and problem-based learning can improve students' creativity, collaboration, and environmental awareness (Diawati, 2022; Nurwidodo et al., 2024). However, the originality indicator showed lower improvement compared to other indicators, suggesting that students still require more opportunities to develop unique and innovative ideas independently.

In addition, the integration of plastic waste management with hydroponic installations provided meaningful learning experiences because students could directly connect science concepts with environmental sustainability issues (Azaza, et al., 2025). Through authentic environmental problems, students became more actively involved in inquiry, discussion, and collaborative learning processes. This supports the view that contextual science learning improves not only conceptual understanding but also environmental responsibility and creative problem-solving skills (Bybee, 2019). Therefore, the developed PBL learning devices can be considered a relevant and effective approach for supporting creative thinking development and environmental education in junior high school science learning.

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CONCLUSION

Based on the results of the research and analysis that have been carried out, it can be concluded that the problem-based learning model learning device with the material on plastic waste management for hydroponic installations is quite effective in improving students' creative thinking skills.

FUTURE DIRECTIONS

Future research is recommended to focus on the implementation and effectiveness testing of Problem-Based Learning (PBL) learning devices on plastic waste management materials integrated with hydroponic installations in junior high school science learning. Empirical studies involving experimental or quasi-experimental designs are needed to examine the impact of these learning devices on students' creative thinking skills, environmental literacy, and problem-solving abilities. Further investigations may also explore how different learning environments and student characteristics influence the effectiveness of PBL-based environmental learning.

In addition, future studies should develop more innovative and technology-integrated learning devices, such as digital worksheets, virtual simulations, and STEM-based project modules related to hydroponic systems and plastic waste recycling. Research involving interdisciplinary approaches and sustainable education perspectives is also important to strengthen the relevance of environmental learning in addressing real-world ecological challenges. Expanding the implementation across different educational levels and regions may provide broader insights into the scalability and adaptability of PBL learning devices for environmental science education.

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