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The Effect of STEAM Project-Based Learning Approach Towards Student Learning Motivation: Utilization of Plastic Waste with Ecobricks Technique

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Abstract: The exponential increase in plastic production and the surge in plastic waste have led scientists and researchers to look for innovative and sustainable ways to recycle plastic waste to reduce its negative environmental impact. Project-Based Learning (PjBL) based on STEAM (Science, Technology, Engineering, and Mathematics) with ecobricks is one of the learning solutions for reducing plastic waste and increasing student motivation. This study aimed to determine the effect of the STEAM-based PjBL model with ecobricks techniques that can improve student learning motivation on ecology. This type of research is pre-experimental One-Group Pretest-Posttest Design. The sample in this study was 25 respondents. The sampling technique used by researchers was purposive sampling. The results of the study showed that based on the pretest in this study 55.28 after treatment was given to 25 respondents, the posttest results were 74.96. Other findings also showed a difference in the average value between the pretest and posttest. The sig. (2-tailed) value of 0.001 <0.05 then H0 is rejected and Ha is accepted, meaning that the steam-based project-based learning model is effective in increasing student learning motivation. Thus, STEAM-based PjBL with ecobricks techniques can improve the learning motivation of elementary school students.

Keywords: PjBL, STEAM, ecobricks, learning motivation.

▪ INTRODUCTION

Plastic waste management is a growing concern that it can harm wildlife and ecosystems. Ultimately, policy is critical to mitigating the environmental impacts of plastics (Castro-Amoedo et al., 2024). According to a United Nations Environment Program report, about 300 million tons of plastic waste is generated each year globally, while only 9% of plastic waste is ever recycled (Lamba et al., 2022). Plastic waste handling, including in Bangladesh, has become a significant environmental and social issue worldwide. Six hundred and forty-six metric tons of plastic waste are collected daily in Bangladesh, but only 10% of that waste is recycled, and 37.2% must be disposed of properly. Many techniques are used to recycle plastic waste worldwide, but Bangladesh wants to recycle 50% of its plastic waste (Abdullah & Abedin, 2024). According to the Nova Chemicals survey, Indonesia is the second largest contributor to marine debris after China, at 1.29 million metric tons/year. Currently, many people in Indonesia still throw garbage everywhere, which can cause flooding in the river. Plastic waste is tough to decompose; it takes more than 100 years to decompose or completely decompose plastic (Haribowo et al., 2017). The US and most European countries have modern and complete waste disposal infrastructure, and estimates show that up to 3% of all plastic production leaks into the environment which eventually ends up in the ocean, usually in the form of microplastics, which are a danger to all marine fauna and humans. (Law et al., 2020). In the European context, Italy is the second producer and consumer of plastics after

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Germany (Rossi & Bianchini, 2022). Plastic waste can potentially cause negative impacts on the environment, including a decrease in structural integrity and fragmentation into smaller fragments when exposed to stressors (Zjačić, 2023). Plastic debris can release toxic chemicals into the atmosphere, causing airborne diseases and endangering human health. Plastic debris can affect the composition and activity of microbial communities in marine habitats, thereby increasing the abundance of pathogenic bacteria and genes associated with antibiotic resistance (Vlaanderen et al., 2023).

The invention of plastic as a material that is beneficial to human life provides comfort and convenience. However, plastic has become a threat to society because it has also become a shared habitat of the human ecosystem. Plastic can be easily modified from one form to another based on the desired function. Plastics are polymers or "long chains of monomers" bonded together. It is the identical subunits that form a polymer. Polymers can come from nature, such as cellulose, an essential subunit that forms plant cell walls and helps cells customize their functions (Qamar et al., 2020); (Asgher et al., 2020). Cellulose is known as one of the most abundant biopolymers on earth. The first synthetic polymer was discovered around 1869 by John Wesley Hyatt. It was costly compared to polymeric materials. Today, plastics are increasingly used in our daily activities, including packaging in various food and brewing, cosmetics, pharmaceuticals, and other production sectors, which need to package their end products for efficient and safer delivery of products to the public. Plastics are produced through the biochemical process of polymerization or polycondensation (Evode et al., 2021).

Humans make plastics, yet plastics now live far longer than the humans who gave them the privilege of existence. Since this material colony cannot be eradicated, finding possible ways to eliminate it is imperative. One such method is beneficial diversion through recycling by converting plastic bottle waste into valuable raw materials for the economic sector (Babaremu et al., 2022). Most plastics are not and have never been recycled (9%), yet most are dumped into environmental landfills (79%) or incinerated (12%) (Geyer et al., 2017). About 80% of building occupants dispose of plastic waste in their gardens and burn it around their homes. Some developed countries have used plastic bottles for construction and converted plastic into vases for horticultural flowers (Nováková et al., 2017). In addition, cardboard beds in the 2020 Tokyo Olympics are eco-friendly. The bed frame is recycled cardboard (Jivkov et al., 2021). There is also furniture made from used cardboard, but usually, the structure is relatively simple. Even building construction components are being experimented with using sheets of waste cardboard collected from the waste stream. Corrugated cardboard has a good strength-to-weight ratio, excellent burst strength, and resistance to crushing, making it an ideal material for furniture manufacturing (Suarez et al., 2021).

The government of Ambon City, Indonesia, banned the provision and use of plastic bags in all modern retailers to reduce plastic waste. Single-use plastic shopping bags are a significant source of environmental pollution (Jambeck et al., 2015; Xanthos & Walker, 2017). The implementation of reducing the use of plastic bags is one way to reduce plastic waste in Ambon. Head of the Ambon City Environment and Solid Waste Office, Alfredo Hehamahua, through the mass media on Wednesday, 10 July 2024, said that the efforts made were by Presidential Regulation Number 97 of 2017 concerning National Policies and Strategies for the Management of Household Waste and Waste Similar to Household Waste and other provisions in Government Regulation Number 97 of 2017 which were

elaborated in Mayor's Regulations Number 43 and 45 of 2018 concerning Reducing the Use of Plastic Bags. We urge people who want to shop to prepare non-plastic grocery bags to make purchases at modern retailers and other stores. The Ambon City Environment and Solid Waste Office recorded that the percentage of plastic waste in the capital city of Maluku Province reached 30 percent of the total waste volume of 246.74 tons per day. Approximately 30 percent of plastic waste is generated daily in Ambon City from a total volume of 246.74 tons per day. He said government intervention against waste in Ambon City has been carried out with various efforts, starting from regulating the time of waste disposal to temporary disposal sites and transportation to landfills. In addition, plastic waste management through waste banks at Reuse, Reduce, and Recycle (TPS3R) waste management sites to restrictions on the use of plastic packaging.

Ecobricks are innovations in construction that utilize plastic waste to produce of construction units. Ecobricks production involves the use of polyethylene terephthalate (PET) bottles, a plastic material widely used for packaging soft drinks and water (Akbar et al., 2023; Groh et al., 2019). According to research by the Ministry of Environment and Forestry (2020) and UNEP, Indonesia's food and beverage industry uses PET for its packaging, accounting for 60% of total plastic production. However, the other side of PET is that it is petroleum-based and does not readily decompose when released into the earth's environment through plastic waste leakage (Benyathiar et al., 2022). Ecobricksing is one creative attempt to turn plastic waste into valuable goods, reducing the pollution and toxins caused by plastic waste. The technique is simple and easy to implement, so it can quickly spread through social networks (communities, villages, and schools). Ecobricks aims to reduce plastic waste and recycle it by using plastic bottles as a medium to create something useful. The shift towards a student-centered learning paradigm is one way to improve the quality of education. This paradigm could be implemented in problem-based learning, where students are placed as the subject of learning. Such an educational system can help the development of an enjoyable and comfortable learning experience for students (Mukholifah, 2023).

Project-based learning (PjBL) presents real problems to students in developing their ability to have higher-order knowledge, inquiry, and skills, become independent, and increase knowledge, inquiry, and higher-order skills and self-confidence (Yulhendri et al., 2023). PjBL can motivate students to develop learning outcomes, as it requires a process called reflection that helps students focus on the learning objectives to be achieved (Hira & Anderson, 2021). The real problem faced by society today is related to plastic waste. Therefore, educators must be able to improve students' ecological literacy in solving environmental problems through learning. Many educators believe that the founder of PjBL is the American philosopher Kilpatrick, a follower of Dewey who stated that teaching should focus on guiding inquiry directed at real-world problems, as well as Vygotsky's (1978) ideas about the importance of social interaction in the learning process (Goldstein, 2016). PjBL is slowly entering educational reform in the form of a new teaching strategy that aims to develop various skills and competencies and increase learners' motivation to utilize educational materials (Awamleh, 2024). The advantages of the PBL approach in teaching are enormous (Holm, 2011): (1) students develop motivation and take responsibility for their learning; (2) they create their integrated knowledge and understanding; (3) the knowledge is sustainable over a long period; (4) students learn to communicate through problem-solving; (5) they experience a variety of

learning tasks; and (6) they get responses to their learning needs. PjBL has been shown to positively influence students' academic achievement while fostering their intrinsic motivation and playing an essential role in cultivating sustainable learning capacity (Wu, 2024). PjBL is gaining increasing attention in contemporary education due to its ability to develop academic achievement and intrinsic motivation among learners (Chen, 2018). At the same time, self-directed learning (SRL) has become an essential factor influencing learner success and long-term learning outcomes. SRL stands as a fundamental and multifaceted concept empowering learners to exercise control and guidance over their learning behavior, thus emerging as an essential factor in shaping and fostering autonomy (Stefanou et al., 2013).

STEAM-based PjBl learning is conducted to facilitate mentoring and training on the dangers of plastic waste and waste management through ecobricks techniques with high utility value. The community begins to understand why we need ecobricks, and ecobricksing can be used as a garden decoration, which is an alternative solution to the over-utilization of plastic waste through creative community empowerment activities. PjBL with a STEM approach utilizing plastic waste with ecobricksing methods to improve students' ecological literacy in solving environmental problems. PjBL can enhance skill-based learning, creativity, and attitudes in student science and STEAM education (Chistyakov et al., 2023).. STEAM education significantly improves preschoolers' learning engagement, cognition, confidence, and innovative thinking skills. The integration of content about local culture into STEAM projects also triggers students' awareness and engagement with the surrounding community and society. However, teacher competence and willingness to implement STEAM activities are irreplaceable in determining the frequency and effectiveness of STEM projects (Bui et al., 2023). In Catalonia, Spain, STEAM education is gaining prominence at the policy and academic levels, coinciding with a broader innovation movement embracing PBL as a preferred teaching and learning approach (Pérez Torres et al., 2024).

Studies confirm that new STEM graduates have a spirit of innovation and creativity. The STEM market is increasing three times faster, and only 4.4% of American college students are enrolled in STEM programs, so qualified workers well-versed in developing high-tech skills are needed (Land, 2013). That is why the US is working to adopt the STEAM approach, which equips students with high-tech skills in a way that represents creativity in an art form that reduces stress and anxiety, encourages students to explore and increases their internal motivation, and positively impacts student learning (Mater et al., 2023). STEAM may, on the one hand, increase motivation and, on the other hand, help to encourage critical thinking about real-world problems so that science learning becomes more exciting and enjoyable (Conradty & Bogner, 2019).

The results showed that STEAM Project-based learning approach could significantly improve students' science literacy skills compared to traditional learning. (Eren, 2021). The PjBL approach teaches several essential strategies for the 21st century. (Bell, 2010) While STEAM is more of a grand strategy. A strategy that aims to incorporate a broader range of disciplines (Belbase et al., 2022). Although the attributes of both concepts are similar, STEAM Project-Based Learning Approach focuses more on the design process and serves as a systematic approach to finding appropriate problem solutions (Capraro & Slough, 2013). The STEAM Project-based learning approach can help students understand science concepts in the classroom. It can also be used to improve

the science literacy skills of elementary school students through the involvement of educators from various fields in designing learning plans (Queiruga-Dios et al., 2021). PjBL-STEAM affects learning achievement and student motivation. Motivation in learning is essential. The results of a study in Japan show that female students have higher learning motivation than male students (Tanaka, 2023). Each learner has a different level of motivation to learn in school, depending on the needs to be achieved. This variation in learning motivation levels is a challenge in achieving learning goals in primary schools. In the study results of Terrón-López et al., (2017) regarding PJBL learning, teachers and students seem to be more motivated. Students think that they have acquired more skills that are likely to create real projects that will bring them closer to the professional world. Students have perceived an improvement in academic performance, and teacher satisfaction has also increased. Combining STEAM Project-based learning approach utilizing plastic waste with the ecobricks method can improve students' ecological literacy in solving environmental problems. Therefore, this study aimed to determine the effect of the STEAM project-based learning approach with the ecobricks technique on increasing students' learning motivation on ecology.

▪ METHOD

Participants

The sample in this study was 5th-grade students at SD Negeri 73 Ambon, as many as 25 people. The sampling technique was purposive sampling. Purposive sampling is determining a sample based on a specific purpose or determined because it is closest and knows the information or problems being studied. In addition, purposive sampling was used to select respondents who were most likely to provide appropriate results and helpful information (Campbell et al., 2020). This sample return technique has specific considerations, including the criteria of students with low learning motivation.

Research Design and Procedures

This research applies experimental methods with a pre-experimental research type, the type of pre-experimental used was one-group pretest-posttest design. STEAM Project-Based learning approach and research instruments are the main things that must be prepared before the research occurs. According to scientific ethics, researchers, in this case, acting as teachers, need to obtain official research permission from related parties, including school leaders. Teachers also provide explanations to school leaders and students about learning with the STEAM Project-based learning approach. The data collection procedure begins with giving a pretest of learning motivation to determine the profile of student learning motivation before the STEAM Project-based learning approach is implemented. Science learning with the STEAM Project-based learning approach was conducted for four meetings. The topic studied was waste recycling. After all the science learning with the STEAM Project-based learning approach is completed, the teacher asks students to fill out a learning motivation questionnaire.

Instrument

Instrument analysis in this study consists of validity (0.396) and reliability (0.844). This was done so that the instrument becomes a valid and reliable measuring instrument. Before being used in data collection, research instruments are validated by 3 results, namely biology learning, basic education and technology experts from Pattimura

University. This study used an instrument in the form of a learning motivation questionnaire. The preparation of the question instrument begins with the preparation of a learning motivation blueprint, which is then made in the form of a statement. In filling out this questionnaire, students can express attitudes in five choices/categories, namely: strongly agree (SS), agree (S), neutral (N), disagree (TS), and strongly disagree (STS). In the study, the instrument used was a questionnaire containing 20 items. The blueprint of the learning motivation questionnaire is in Table 1.

Table 1. Indicators of measuring student learning motivation

Indicators	Statement Items
Perseverance	
Measures how persistent students face learning difficulties and achieve their learning goals.	1. 2. 17 and 18
Task Orientation	
Measures students' interest in learning tasks and the effort to understand the subject matter.	3. 4. 5. 6. 7. 14. 15 and 16
Goal-oriented	
Measures the extent to which students have clear learning goals and the efforts made to achieve these goals.	8. 9. and 10
Extrinsic Motivation	
a. Rewards and Praise Measures how much student motivation is influenced by external factors such as rewards and praise.	11. 12
b. Punishment Measures how much students avoid negative behaviors (such as lazy studying) due to fear of punishment.	13
Engagement in the Learning Process	
measuring the level of student activeness in learning activities in the classroom	19 and 20

Data Analysis

The data collection techniques used in this study were observation and questionnaire distribution. The data analysis technique used is non-parametric statistics with a T-test. Researchers want to know two different subject conditions after and before treatment is given to 5th-grade students using the STEAM Project-based learning approach. The data analysis technique used was the T-test using the Wilcoxon test to see the pretest and posttest results and whether there was a difference between students who had not been treated and those who had been given treatment. Other data analysis techniques are validity, reliability, normality, and homogeneity tests. To test the data analysis above, researchers utilized the SPSS 23 application. Quantitative data is a motivational instrument in the form of a questionnaire consisting of statements. The questionnaire approach used in this study was a Likert scale. Each statement in the Likert scale questionnaire has a different score. After processing the questionnaire data, the next

step was to interpret it. Then, it was described so that it could be known whether students have a positive or negative attitude towards ecobricks learning.

▪ RESULT AND DISSCUSSION

IPAS Learning with STEAM Project-based Learning Approach

The topic of the IPAS lesson is waste recycling. The description of the STEAM approach in the lesson is as follows: 1) Science (S) aspect, students learn about the recycling process, types of waste, and its impact on the environment. 2) Technological aspect (T): Students recognize various tools and technologies used in the recycling process. 3) Engineering (E), students design and build ecobricks. 4) Arts (A), students design a simple ecobricks plastic table/chair. 5) Mathematical (M): Students calculate the number of ecobricks needed.

The implementation of the STEAM Project-Based learning approach is explained as follows. In the first meeting, the fundamental question phase, students were given an overview of the waste problem in Ambon through a video presentation. Furthermore, students are invited to observe the environment around the school to find out the types of waste and the amount, as well as efforts to deal with waste problems in Ambon. Then, the teacher provides discussion questions for the three groups to explore information about the impact of waste on the environment and how to overcome it. One of the ways is with ecobricks. Students were asked to design an ecobricks project at the project design stage. Students discuss in groups how to design the project. The teacher assigns students to complete the ecobricks design task at home.

In the second meeting, students continued the following week's learning by delivering ecobricks design presentations. The three groups tried to design ecobricks into building materials such as chairs or simple tables. In the third stage of PjBL, the teacher guided the students in developing a schedule of project activities. This schedule was a reference for teachers and students in learning.

The STEAM Project-Based learning approach in the third meeting focused on project implementation and monitoring. In this phase, students made ecobricks projects using plastic waste and aqua bottles that they had collected. Previously, students took the initiative to collect some plastic waste. One aqua bottle can hold about 2 kg of plastic waste in the form of candy or snack packs, detergents, plastic bags, and other plastics. Students will fold them into small pieces and put them into the aqua bottle, sealing it until it is full. If one simple chair/desk requires 9 1500 mL aqua bottles, then one simple chair/desk can accommodate 18 kg of plastic waste. Students also use designs made previously through assistance from the teacher. Students' motivation in learning is seen in their initiative to collect waste, be responsible for it, and bring it to school. In learning, students seemed to enjoy the different learning atmosphere. If, in daily life, students sit sweetly in their respective chairs to learn, some of them are sitting or standing while working to take care of the plastic waste until it becomes crowded in an aqua bottle. Furthermore, the rows of aqua bottles were assembled to form a simple table/chair.

The STEAM Project-Based learning approach focused on result assessment and experience evaluation in the fourth meeting. Students made a simple table/chair from bottles and plastic waste. The results of this project were then submitted to the teacher to provide assessment and feedback. At the same time, the teacher gave an oral evaluation

of the student's learning motivation related to the learning procedure for making ecobricks. The following is an excerpt of the teacher's interview with the students.

Teacher : Are you challenged to tackle the waste problem? What concrete steps have you taken?
Student 1 : Yes, quite a challenge. The ecobricks we have made are a way of tackling the waste problem.
Student 4 : I need to make an effort to solve the waste problem by putting trash in its place and making ecobricks.
Teacher : What was the most interesting thing you experienced while ecobricksing?
Student 6 : When cutting up the garbage and putting it in the plastic bottle, the group worked together until it was finished.
Student 11 : When designing ecobricks into a simple chair.
Teacher : Why are you motivated to collect waste?
Student 10 : Because plastic waste is dumped everywhere, around my house, too.
Student 13 : Because if plastic waste is left unattended, it will be washed away when it rains, (waste) causing flooding.

Pretest and Posttest Comparison

After the treatment results were obtained, the next step was to analyze the treatment result data by conducting a different test with the Wilcoxon test. Therefore, it is necessary to know the comparison before being given treatment through the STEAM Project-based learning approach with ecobricks techniques to increase student learning motivation (pretest) and after being given treatment using ecobricks learning to increase student learning motivation (posttest), which is shown in Figure 1.

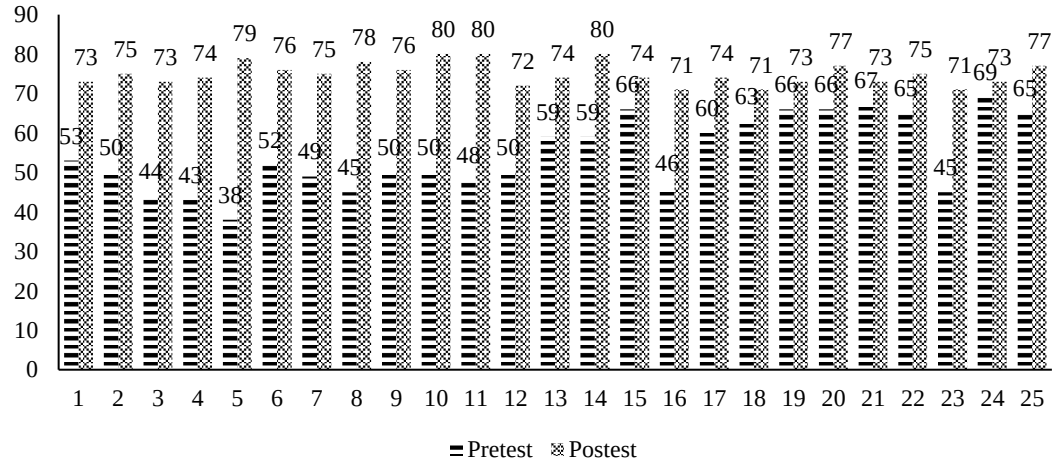

Figure 1. Comparison of pretest and posttest

Based on the data in Figure 1, there is an increase in scores on student learning motivation that has been given treatment than before treatment; the number of scores before treatment is 1382, has an average of 55.28, and those who have been given treatment have a total of 1874, has an average of 74.96. Therefore, it can be seen that the learning motivation of grade 5 students can increase after being given treatment.

Hypothesis Test

Table 2. Test statistics (hypothesis test)

Test Statistics	
	POSTTEST - PRETEST
Z	-4.287[b]
Asymp. Sig. (2-tailed)	.000
a. Wilcoxon Signed Ranks Test	
b. Based on hostile ranks.	

Based on Table 2, the value of asymp can be understood. Sig. (, 000). Therefore, this indicates that H0 is rejected and Ha is accepted, Sig. (2-tailed) (0.000) <0.05 means that the effectiveness of STEAM Project-Based learning approach is significant to increase student motivation. During the learning process, students showed enthusiasm in arguing and responding to questions from the teacher. They actively discuss design ecobricks with innovations and can communicate ideas or innovative ideas related to a problem in front of the class. Students were eager to complete the project assignments. Based on the literature review, this research proposed the pedagogical STEAM (Scaffolding et al., and Modeling) model shown in Figure 1 that can be used to design an interdisciplinary curriculum. Based on the curriculum activities developed by teachers, interdisciplinary learning scaffolding is provided to students to help them understand and complete the learning tasks for each stage of the project (Lin & Tsai, 2021).

Figure 2. The pedagogical STEAM model (Lin & Tsai, 2021)

Science learning activities at school are carried out as usual, but as a simulation in environmental pollution learning it is slightly different, it can be seen that the science teacher brought several empty bottles, several unused plastics, scissors, and wooden sticks. Several students asked about the objects brought by the teacher before the lesson

began. Learning begins with providing motivation and counseling about the importance of protecting and preserving the environment, followed by providing environmental pollution material, and this learning is supplemented with a demonstration method to demonstrate how to make ecobricks from materials brought to class. Students are also given the task of bringing as many materials as possible to be made as exemplified by the teacher for making ecobricks the next day. Efforts to manage waste using the ecobricks method can be a solution to reduce plastic waste by utilizing it as furniture (chairs, tables), plant rooms, walls, and even entire buildings. Thus, this ecobricks method can reduce plastic pollution in the surrounding environment. Ecobricks can empower individuals to be responsible for their waste owners from the source. The technique is simple and very easy, so it can spread quickly through social networks (communities, villages, schools, etc.).

Through STEAM Project-Based learning approach activities with ecobricks techniques, students can gain insight into waste sorting and waste management. Ecobricks is one of the creative efforts to handle plastic waste. Its function is not to destroy plastic waste but to extend the life of the plastic and process it into something useful, which can be used for the general benefit of humanity. Ecobricks through the green pollution module explains that the ecobricks concept has the potential to be applied in environmental pollution studies. Making ecobricks is still not very popular among the wider community. Most people. Still treat used plastic as household plastic waste, polluting the environment, and rivers, and polluting everyday life without self-awareness. For this reason, more intensive socialization is needed regarding creative plastic waste processing. Starting from household plastic waste. With a little effort, one important problem will be solved little by little. Science learning media made from used goods such as plastic are suitable for use as learning media. In fact, several learning media are suitable for production for sale that are made of plastic. The motivation and learning outcomes of students who use tapioca waste learning resources are higher than those who use conventional learning resources. Teachers who implement ecology-based learning in schools, especially those accompanied by entrepreneurial principles, will have a positive impact on students. The implementation of ecopreneurship-based learning will make students never give up, be able to turn challenges into opportunities, be independent, and responsible, and behave ecologically that can manage, utilize, and maintain the surrounding natural environment. In this case, students who process plastic waste into ecobricks will certainly reduce the amount of plastic waste scattered around. so that the environment becomes clean (Aqil et al., 2023).

Applying the STEAM Project-Based learning approach with ecobricks in elementary schools can motivate low-achieving students to be more interested in learning and reduce the achievement gap (Breiner, 2012). Students from an early age have been trained independently by utilizing waste to become exciting products. Using ecobricksing techniques can reduce community waste production and be developed into high-quality products such as ecobricks (Edike et al., 2024) and reading gardens (Ariyani et al., 2024). This can be seen in Yelwa Village, Nigeria, where the first bottle bricks were built in Africa with ecobricks for house construction in rural communities, as shown in Figure 2. The aim is to help reduce plastic waste in the community. Apart from reducing plastic waste from the environment, ecobricks possess a comparable indoor thermal environment with conventional clay brick houses (Mokhtar et al., 2016). Mokhtar stated that the

relative humidity of both regular brick houses and ecobricks greenhouses are 40% to 70% and 59% to 73% respectively, satisfying the requirement for indoor air quality of buildings. The embodied manufacture energy of ecobricks is approximately 0.346 MJ/kg engendering considerably low life cycle energy of ecobricks houses compared to buildings constructed with concrete blocks. These studies have indicated that ecobricks promote energy efficiency in buildings, and have the potential to reduce the energy consumption of the construction industry.

Figure 3. Plastic bottle bricks wall with steel truss roof and metal window frame (Edike et al., 2022)

The results of a study in Taiwan show that most high school students are considered low-ability students, and many students in vocational high schools have low motivation to learn. Most of them feel that they cannot learn; in other words, they have low motivation to learn. In addition, most junior high school students attend a learning environment full of teacher-centered instruction. Students are used to receiving step-by-step instructions. The knowledge learned from textbooks and exams is unfamiliar to apply in daily life and the jobs they take. When these students enter vocational schools that emphasize the practice of hands-on knowledge and skills, few of them have problem-solving experience. Hence, vocational school teachers have difficulty teaching students problem-solving (Chiang, 2016). Some researchers indicate that students' independent learning can be stimulated in PjBL activities, and some research results show that PjBL can potentially improve affective domains, including attitudes and self-efficacy beliefs (Duke et al., 2021). Student motivation is stimulated in various ways in PjBL environments, such as formal and informal group discussions, regular supervisor meetings, and shared leadership. In summary, evidence of the potential of the PjBL approach, particularly in facilitating learning achievement and student motivation, is abundant (Liu et al., 2006). Incorporating STEAM Project-Based learning approach as a buzzword in the school environment places it as the focus of many academic and training calls. As is well known, STEM emerged in the United States in the 1980s, in a neoliberal era of political and socioeconomic background, in apparent competition with emerging great powers such as China (Bautista, 2021), North Korea, and Russia.

In addition, STEAM Project-Based learning approach can improve science literacy, make learning more exciting and motivating, help understand teaching materials, form

creative attitudes, and increase students' awareness of the importance of preserving the environment. Applying PjBL+STEAM provides new experiences for students, increasing their motivation and interest in learning material about environmental pollution. The PjBL-STEAM model also has a positive effect on increasing learning motivation and improving students' problem-solving skills (Dacumos, 2023). STEAM Project-Based learning approach has various advantages, which encourage students and teachers to conduct in-depth investigations, problem-solving, collaboration, and development of critical thinking skills that reflect real-world problems with a focus on a specific end product. Meanwhile, the STEAM approach has a planning and redesigning process that allows students to produce their best product. Integrating STEAM aspects can positively impact students, especially in problem-solving, increasing their learning motivation and supporting their future careers. Therefore, the implementation of STEAM Project-based learning approach affects students' learning motivation. In its implementation, students are given a project framework that helps them find problem-solving solutions to complete project tasks within the specified time. Project-based learning involves students in a series of activities ranging from planning, designing, and implementing to reporting the results of activities in the form of products. This is in line with research by Baran et al., (2021) The PjBL model emphasizes the long-term learning process and direct involvement in various issues and problems of everyday life. It also teaches how to understand and solve real problems. This model is interdisciplinary and involves students as the main actors, from designing and implementing to reporting the results of activities.

Figure 4. Ecobricks results

The picture above results from ecobricks produced by 5th-grade students of SD Negeri 73 Ambon. Students worked together to put plastic waste into plastic bottles until it was solid and designed it into a simple chair like the picture above. This activity is not only beneficial for the environment but also provides many educational benefits for students. We can all be inspired by the positive actions of SDN 73 Ambon students to start applying the 3R principles (Reduce, Reuse, Recycle) in our daily lives and contribute to preserving the environment. Ecobricks are PET bottles filled with several materials that can be used as building blocks (Taaffe et al., 2014). There are experiences with bottles filled with soil and others filled with compressed inorganic waste materials, particularly plastics, foam, packaging, and plastic (Martínez et al., 2016). The public and non-governmental organizations (NGOs) consider Ecobricks as a legitimate recycling way to reduce the volume of plastic waste disposal (Antico et al., 2017). Moreover, these handmade building blocks have become accessible/low-cost construction materials for social projects in areas where waste and informal landfills are a common problem, and industrial recycling may not yet be available. Examples of regions where ecobricks building projects have been reported include countries in Latin America, Africa, and South Asia (Taaffe et al., 2014).

▪ CONCLUSION

Based on the above explanation, it can be concluded that the STEAM Project-Based learning approach with ecobricks techniques in learning science on ecological material positively affects student learning motivation. This is because students are encouraged to explore the work or tasks according to their creativity and work independently or in groups. Learning motivation can improve student learning outcomes, closely related to the learning process. Thus, the application of the STEAM Project-Based learning approach can increase student learning motivation. It is expected that there is an awareness that plastic waste that cannot be recycled can be utilized to create other forms that are more useful and have economic value. For further activities to be carried out, trials using various types of plastic waste can be utilized for various innovative works so that the general public can widely use them.

This study is valuable because it can help reduce plastic waste in the school environment while inviting students to be able to manage waste properly with useful things, in addition to integrating school learning in science learning or local content that utilizes waste into superior school products and is also expected to inform policy considerations and directions towards creating an innovation-friendly environment in the housing sector. This study still has limitations in elementary school students and is expected to be applied to higher-level students in the future.

▪ REFERENCES

Abdullah, M., & Abedin, M. Z. (2024). Assessment of plastic waste management in Bangladesh: A comprehensive perspective on sorting, production, separation, and recycling. Results in Surfaces and Interfaces, 15(April), 1–18. https://doi.org/10.1016/j.rsurfi.2024.100221

Akbar, R., Nurhasana, R., Oktorini, R., Indrajoga, D. N., Harjito, U., Hernandi, R., Ratnasari, D. N., Hanna Grace Waruwu, A., & Budi Hartono, I. (2023). Utilization

of plastic waste into garden decoration using ecobricks techniques. Indonesia Journal of Community Service, 4(1), 130–138. https://doi.org/10.22219/

Antico, F. C., Wiener, M. J., Araya-Letelier, G., & Retamal, R. G. (2017). Ecobricks: A sustainable substitute for construction materials. Revista de La Construccion, 16(3), 518–526. https://doi.org/10.7764/RDLC.16.3.518

Aqil, D. I., Gayatri, A. M., & Sari, A. I. C. (2023). Ecobricks is reviewed as the source of learning, creativity, and environmental care attitude (Vol. 1). Atlantis Press SARL. https://doi.org/10.2991/978-2-38476-096-1_10

Ariyani, D., Nur Arini, R., Trisno Lestari, R., & Kurnia, F. (2024). Ecobricks as a sustainable solution: designing an eco-friendly reading garden to reduce plastic waste. Wikrama Parahita : Jurnal Pengabdian Masyarakat, 8(1), 105–111.

Asgher, M., Afzal, M., Qamar, S. A., & Khalid, N. (2020). Optimization of biosurfactant production from chemically mutated strain of Bacillus subtilis using waste automobile oil as low-cost substrate. Environmental Sustainability, 3(4), 405–413. https://doi.org/10.1007/s42398-020-00127-9

Awamleh, W. (2024). The effectiveness of e-project-based learning in improving the academic achievement and motivation of special education female students. Cogent Education, 11(1), 1–18. https://doi.org/10.1080/2331186X.2024.2369968

Babaremu, K. O., Okoya, S. A., Hughes, E., Tijani, B., Teidi, D., Akpan, A., Igwe, J., Karera, S., Oyinlola, M., & Akinlabi, E. T. (2022). Sustainable plastic waste management in a circular economy. Heliyon, 8(7), 1–6. https://doi.org/10.1016/j.heliyon.2022.e09984

Baran, M., Baran, M., Karakoyun, F., & Maskan, A. (2021). The influence of project-based STEM (PjbL-STEM) applications on the development of 21st-century skills. Journal of Turkish Science Education, 18(4), 798–815. https://doi.org/10.36681/tused.2021.104

Bautista, A. (2021). STEAM education: contributing evidence of validity and effectiveness (Educación STEAM: aportando pruebas de validez y efectividad). Infancia y Aprendizaje, 44(4), 755–768. https://doi.org/10.1080/02103702.2021.1926678

Belbase, S., Mainali, B. R., Kasemsukpipat, W., Tairab, H., Gochoo, M., & Jarrah, A. (2022). At the dawn of science, technology, engineering, arts, and mathematics (STEAM) education: prospects, priorities, processes, and problems. International Journal of Mathematical Education in Science and Technology, 53(11), 2919–2955. https://doi.org/10.1080/0020739X.2021.1922943

Bell, S. (2010). Project-based learning for the 21st century: skills for the future. The Clearing House: A Journal of Educational Strategies, Issues and Ideas, 83(2), 39–43. https://doi.org/10.1080/00098650903505415

Benyathiar, P., Kumar, P., Carpenter, G., Brace, J., & Mishra, D. (2022). Reciclaje de botella a botella de tereftalato de polietileno (PET) para la industria de bebidas: una revisión. Polymers, 14(12), 1–29.

Bui, T. L., Tran, T. T., Nguyen, T. H., Nguyen-Thi, L., Tran, V. N., Dang, U. P., Nguyen, M. T., & Hoang, A. D. (2023). Dataset of Vietnamese preschool teachers' readiness towards implementing STEAM activities and projects. Data in Brief, 46, 1–8. https://doi.org/10.1016/j.dib.2022.108821

Campbell, S., Greenwood, M., Prior, S., Shearer, T., Walkem, K., Young, S., Bywaters, D., & Walker, K. (2020). Purposive sampling: complex or simple? Research case examples. Journal of Research in Nursing, 25(8), 652–661. https://doi.org/10.1177/1744987120927206

Capraro, R. M., & Slough, S. W. (2013). Why pbl? why stem? why now? an introduction to stem project-based learning. STEM Project-Based Learning, 1–5. https://doi.org/10.1007/978-94-6209-143-6_1

Castro-Amoedo, R., Granacher, J., Kantor, I., Dahmen, A., Barbosa-Povoa, A., & Maréchal, F. (2024). On the role of system integration in plastic waste management. Resources, Conservation and Recycling, 201(June 2023), 1–40. https://doi.org/10.1016/j.resconrec.2023.107295

Chen, C. (2018). Revisiting the effects of project-based learning on students' academic achievement: A meta-analysis investigating moderators. In Educational Research Review. Elsevier Ltd. https://doi.org/10.1016/j.edurev.2018.11.001

Chiang. (2016). The effect of project-based learning on learning motivation and problem-solving ability of vocational high school students. International Journal of Information and Education Technology, 6(9), 709–712. https://doi.org/10.7763/ijiet.2016.v6.779

Chistyakov, A. A., Zhdanov, S. P., Avdeeva, E. L., Dyadichenko, E. A., Kunitsyna, M. L., & Yagudina, R. I. (2023). Exploring the characteristics and effectiveness of project-based learning for science and STEAM education. Eurasia Journal of Mathematics, Science and Technology Education, 19(5), 1–7. https://doi.org/10.29333/EJMSTE/13128

Conradty, C., & Bogner, F. X. (2019). From STEM to STEAM: Cracking the code? how creativity & motivation interacts with inquiry-based learning. Creativity Research Journal, 31(3), 284–295. https://doi.org/10.1080/10400419.2019.1641678

Dacumos, L. P. (2023). STEM education and the project-based learning: A review article. STEM Education Review, 1(9), 1–6. https://doi.org/10.54844/stemer.2023.0385

Duke, N. K., Halvorsen, A. L., Strachan, S. L., Kim, J., & Konstantopoulos, S. (2021). Putting PjBL to the test: the impact of project-based learning on second graders' social studies and literacy learning and motivation in low-ses school settings. American Educational Research Journal, 58(1), 160–200. https://doi.org/10.3102/0002831220929638

Edike, U. E., Aina, O., & Adeoye, A. B. (2022). Adoption of ecobricks for housing: the case of Yelwa, Nigeria. African Journal of Science, Technology, Innovation and Development, 14(3), 801–812. https://doi.org/10.1080/20421338.2021.1903735

Edike, U. E., Ekop, I., Idusuyi, D. U., & Nduka, O. D. (2024). Development of predictive model for compressive strength of ecobricks masonry walls using numerical method. Cleaner Waste Systems, 8, 1–14. https://doi.org/10.1016/j.clwas.2024.100148

Eren, E. (2021). European Journal of Educational Research. European Journal of Educational Research, 10(3), 1199–1213. https://www.researchgate.net/publication/348382981_Education_Policies_in_the_Context_of_Political_Communication_in_Turkey

Evode, N., Qamar, S. A., Bilal, M., Barceló, D., & Iqbal, H. M. N. (2021). Plastic waste and its management strategies for environmental sustainability. Case Studies in

Chemical and Environmental Engineering, 4, 1–8. https://doi.org/10.1016/j.cscee.2021.100142

Geyer, R., Jambeck, J. R., & Law, K. L. (2017). Production, use, and fate of all plastics ever made. Science Advances, 3(7), 25–29. https://doi.org/10.1126/sciadv.1700782

Goldstein, O. (2016). A project-based learning approach to teaching physics for pre-service elementary school teacher education students. Cogent Education, 3(1), 1–12. https://doi.org/10.1080/2331186X.2016.1200833

Groh, K. J., Backhaus, T., Carney-Almroth, B., Geueke, B., Inostroza, P. A., Lennquist, A., Leslie, H. A., Maffini, M., Slunge, D., Trasande, L., Warhurst, A. M., & Muncke, J. (2019). Overview of known plastic packaging-associated chemicals and their hazards. Science of the Total Environment, 651, 3253–3268. https://doi.org/10.1016/j.scitotenv.2018.10.015

Haribowo, R., Yoshimura, M., Sekine, M., Imai, T., Yamamoto, K., Higuchi, T., & Kanno, A. (2017). Behavior of toxicity in river basins dominated by residential areas. Contemporary Engineering Sciences, 10(7), 305–315. https://doi.org/10.12988/ces.2017.7116

Hira, A., & Anderson, E. (2021). Motivating online learning through project-based learning during the 2020 COVID-19 pandemic. IAFOR Journal of Education, 9(2), 93–110. https://doi.org/10.22492/ije.9.2.06

Holm, M. (2011). Project-based instruction: a review of the literature on effectiveness in prekindergarten through 12th grade classrooms. InSight: Rivier Academic Journal, 7(2), 1–13.

Jambeck, J. R., Geyer, R., Wilcox, C., Siegler, T. R., Perryman, M., Andrady, A., Narayan, R., & Law, K. L. (2015). Entradas de residuos plásticos desde la tierra al océano. Ciencia, 347(6223), 768–771. http://www.sciencemag.org/cgi/doi/10.1126/science.1260879%0Ahttps://www.sciencemag.org/lookup/doi/10.1126/science.1260352

Jivkov, V., Simeonova, R., Antov, P., Marinova, A., Petrova, B., & Kristak, L. (2021). Structural application of lightweight panels made of waste cardboard and beech veneer. Materials, 14(17), 1–17. https://doi.org/10.3390/ma14175064

Lamba, P., Kaur, D. P., Raj, S., & Sorout, J. (2022). Recycling/reuse of plastic waste as construction material for sustainable development: a review. Environmental Science and Pollution Research, 29(57), 86156–86179. https://doi.org/10.1007/s11356-021-16980-y

Land, M. H. (2013). Full STEAM ahead: The benefits of integrating the arts into STEM. Procedia Computer Science, 20, 547–552. https://doi.org/10.1016/j.procs.2013.09.317

Law, K. L., Starr, N., Siegler, T. R., Jambeck, J. R., Mallos, N. J., & Leonard, G. H. (2020). The United States' contribution of plastic waste to land and ocean. Science Advances, 6(44), 1–7. https://doi.org/10.1126/sciadv.abd0288

Lin, C. L., & Tsai, C. Y. (2021). The Effect of a Pedagogical STEAM Model on Students' Project Competence and Learning Motivation. Journal of Science Education and Technology, 30(1), 112–124. https://doi.org/10.1007/s10956-020-09885-x

Liu, W., Wong, A. F. L., Divaharan, S., Peer, J., Quek, C., & Williams, M. D. (2006). Students ' Intrinsic Motivation in Project-Based Learning Using an Asynchronous Discussion Platform. Educational Research Jornal, 21(2), 217–234.

Martínez, I., Etxeberria, M., Pavón, E., & Díaz, N. (2016). Analysis of the properties of masonry mortars made with recycled fine aggregates for use as a new building material in Cuba. Revista de La Construccion, 15(1), 9–21. https://doi.org/10.4067/s0718-915x2016000100001

Mater, N., Daher, W., & Mahamid, F. (2023). The Effect of steam activities based on experiential learning on ninth graders' mental motivation. European Journal of Investigation in Health, Psychology and Education, 13(7), 1229–1244. https://doi.org/10.3390/ejihpe13070091

Mokhtar, M., Sahat, S., Hamid, B., Kaamin, M., Jahaya Kesot, M., Wen, L. C., Xin, L. Y., Ling, N. P., & Lei, V. S. J. (2016). Application of plastic bottle as a wall structure for green house. ARPN Journal of Engineering and Applied Sciences, 11(12), 7617–7621.

Mukholifah, M. (2023). Framework of problem-based learning activities with STEM approach: utilizing plastic waste with ecobricks method in improving students' ecological literacy to solve environmental problems. International Journal of Current Science Research and Review, 06(04), 2654–2665. https://doi.org/10.47191/ijcsrr/v6-i4-46

Nováková, K., Šeps, K., & Achten, H. (2017). Experimental development of a plastic bottle usable as a construction building block created out of polyethylene terephthalate: Testing PET(b)rick 1.0. Journal of Building Engineering, 12, 239–247. https://doi.org/10.1016/j.jobe.2017.05.015

Pérez Torres, M., Couso Lagarón, D., & Marquez Bargalló, C. (2024). Evaluation of steam project-based learning (steam pbl) instructional designs from the stem practices perspective. Education Sciences, 14(1), 1–21. https://doi.org/10.3390/educsci14010053

Qamar, S. A., Ashiq, M., Jahangeer, M., Riasat, A., & Bilal, M. (2020). Chitosan-based hybrid materials as adsorbents for textile dyes–A review. Case Studies in Chemical and Environmental Engineering, 2(June), 1–7. https://doi.org/10.1016/j.cscee.2020.100021

Queiruga-Dios, M. Á., López-Iñesta, E., Diez-Ojeda, M., Sáiz-Manzanares, M. C., & Vázquez-Dorrío, J. B. (2021). Implementation of a STEAM project in compulsory secondary education that creates connections with the environment (Implementación de un proyecto STEAM en Educación Secundaria generando conexiones con el entorno). Infancia y Aprendizaje, 44(4), 871–908. https://doi.org/10.1080/02103702.2021.1925475

Rossi, J., & Bianchini, A. (2022). "Plastic waste free" - A new circular model for the management of plastic. Transportation Research Procedia, 67, 153–162. https://doi.org/10.1016/j.trpro.2022.12.046

Stefanou, C., Stolk, J. D., Prince, M., Chen, J. C., & Lord, S. M. (2013). Self-regulation and autonomy in problem- and project-based learning environments. Active Learning in Higher Education, 14(2), 109–122. https://doi.org/10.1177/1469787413481132

Suarez, B., Muneta, M. L. M., Sanz-Bobi, J. D., & Romero, G. (2021). Application of homogenization approaches to the numerical analysis of seating made of multi-wall corrugated cardboard. Composite Structures, 262, 1–27. https://doi.org/10.1016/j.compstruct.2021.113642

Taaffe, J., O'Sullivan, S., Rahman, M. E., & Pakrashi, V. (2014). Experimental characterisation of Polyethylene Terephthalate (PET) bottle Ecobricks. Materials and Design, 60, 50–56. https://doi.org/10.1016/j.matdes.2014.03.045

Tanaka, M. (2023). Motivation, self-construal, and gender in project-based learning. Innovation in Language Learning and Teaching, 17(2), 306–320. https://doi.org/10.1080/17501229.2022.2043870

Terrón-López, M. J., García-García, M. J., Velasco-Quintana, P. J., Ocampo, J., Vigil Montaño, M. R., & Gaya-López, M. C. (2017). Implementation of a project-based engineering school: increasing student motivation and relevant learning. European Journal of Engineering Education, 42(6), 618–631. https://doi.org/10.1080/03043797.2016.1209462

Vlaanderen, E. J., Ghaly, T. M., Moore, L. R., Focardi, A., Paulsen, I. T., & Tetu, S. G. (2023). Plastic leachate exposure drives antibiotic resistance and virulence in marine bacterial communities. Environmental Pollution, 327, 110. https://doi.org/10.1016/j.envpol.2023.121558

Wu, X. Y. (2024). Unveiling the dynamics of self-regulated learning in project-based learning environments. Heliyon, 10(5), 1–19. https://doi.org/10.1016/j.heliyon.2024.e27335

Xanthos, D., & Walker, T. R. (2017). International policies to reduce plastic marine pollution from single-use plastics (plastic bags and microbeads): A review. Marine Pollution Bulletin, 118(1–2), 17–26. https://doi.org/10.1016/j.marpolbul.2017.02.048

Yulhendri, Y., Prima Sakti, M. R., Sofya, R., Ritonga, M., Alisha, W. P., Sudjatmoko, A., & Susanti, N. (2023). Strategies for project based learning during the pandemic: the benefits of reflective learning approach. SAGE Open, 13(4), 1–18. https://doi.org/10.1177/21582440231217885

Zjačić, P. (2023). From macro to micro plastics; influence of photo-oxidative degradation (p. 463−471).