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STEM Learning for Pre-service Science Teachers through Engineering Design Process (EDP): Project-based Sustainable Development Goals

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Abstract

STEM learning is an integrative and interdisciplinary educational approach that emphasizes the development of critical thinking skills, problem-solving solving and collaboration. This research aims to analyze the implementation of STEM learning and improve the competency of pre-service science teachers in implementing STEM by adopting the Engineering Design Process (EDP). The STEM project theme based on sustainable development goals was chosen with the aim of contributing to achieving the SDGs. Participants in this research were fifth-semester students in STEM courses at IAIN Kudus with a total of 44 students in 2023. This research uses qualitative methods to determine phenomena that emerge and are revealed from time to time. Data was obtained using questionnaire answers, STEM product photos, and STEM product descriptions. This research shows that students are interested in learning STEM projects and improving problem-solving abilities and collaboration abilities. The novelty in this research is the implementation of a STEM project on a theme based on sustainable development goals through the Engineering Design Process (EDP) within the scope of the course.

Keywords: STEM, Pre-service Science Teachers, Engineering Design Process

1. Introduction

STEM education is a standards-based, meta-discipline residing at the school level where all teachers, especially science, technology, engineering, and mathematics (STEM) teachers, teach an integrated approach to teaching and learning, where discipline-specific content is not divided, but addressed and treated as one lively, fluid study (Mahendra, 2022). STEM (Science, Technology, Engineering, and Mathematics) learning is one form of innovative learning that demands a creative and meaningful process. The meaningfulness of this learning is the engineering process. With this engineering process, students not only understand knowledge but also skills that students must understand in getting a concept so that the learning obtained will be more meaningful. STEM learning can be effectively applied to integrative thematic learning because it combines four fields of discipline, namely science, technology, engineering, and mathematics (Oktapiani & Hamdu, 2020).

Each aspect of STEM has specific characteristics that differentiate between the four aspects. Each aspect helps students solve problems much more comprehensively when integrated. The four characteristics are: (1) science that represents knowledge about laws and concepts that apply in nature; (2) technology is a skill or a system used in organizing society, organizations, knowledge or designing and using an artificial tool that can make work easier; (3) engineering is knowledge to operate or design a procedure to solve a problem; and (4) mathematics is a science that connects quantities, numbers, and spaces that only require logical arguments without or accompanied by empirical evidence. All of these aspects can make knowledge more meaningful when integrated into the learning process (Riyanto et al., 2021).

STEM learning is done by combining content/materials in STEM elements into one cohesive unit and taught in an integrated manner, not separately. Thus, students will find learning that not only provides new knowledge and insights in terms of science and mathematics but also applicable knowledge that can be used in everyday life and professional/work life (in terms of machines and technology). This STEM-based education can be integrated and combined with various learning models and methods. This is because STEM education is integrative in nature, allowing various learning models and methods to be used to support its application in the learning process in the classroom. (F. . Aini, 2018). STEM education brings many practical benefits not only for learners but also for their future society. Many studies have pointed out the benefits of STEM education such as Increasing the ability to solve practical problems and increasing creativity for learners.

STEM Project is applied in relation to the United Nations Sustainable Development Goals (SDGs). STEM Project-based Sustainable Development Goals:

- Engage STEM Project with UN Sustainable Development Goals by making links to STEM skills and related themes.
- Consider how the pupil entitlement to Learning for Sustainability can be used as a framework for exploring learning topics including those captured in the Sustainable Development Goals.
- Demonstrate methods of pupil/learner inquiry and highlight examples and opportunities for Interdisciplinary Learning.

Sustainable development is gaining importance in education because of its potential to address social challenges such as environmental degradation, social inequality, and economic instability. Education can play a significant role in promoting sustainable development by equipping students with the knowledge, skills, and values needed to address these challenges. Incorporating sustainability into education helps students develop an understanding of the relationships between social, economic, and environmental systems and how these systems can contribute to sustainable development. In this way, students will gain the skills needed to become responsible and active global citizens who can contribute to sustainable development. (AlAli et al., 2023).

The 17 Sustainable Development Goals (SDGs) associated with the Agenda measure the starting points set by countries in the region towards a new shared vision of sustainable development in line with the 2030 Agenda and analyze and develop ways of implementing them. The SDGs also provide planning and follow-up tools at the national and sub-national levels, and their long-term approach enables everyone to move towards sustainable, inclusive, and environmentally sound development through the formulation of public policies and budget instruments that support countries. The 2030 Agenda is a civilized agenda that promotes dignity and equality. Its implementation is visionary and ambitious and requires the participation of all sectors of society and countries (Vereinte Nationen, 2018).

Science learning activities using STEM based on Sustainable Development Goals can be carried out through engineering design process (EDP) Guidance. (Nusyirwan &

Prayetno, 2020). The engineering design process (EDP) is a decision-making process, often repetitive, in which basic scientific, mathematical, and technical concepts are applied to develop optimal solutions to meet the goals targeted. Teachers can easily apply EDP in classroom projects or activities.

The Engineering Design Process is a series of steps that engineers use to guide them in solving problems. Engineers must ask questions, envision solutions, plan designs, build models, experiment and test the models, and then spend time refining the original models. (Hoban & Delaney, 2011). Most engineering designs can be classified as inventions—devices or systems created by human effort that either did not exist before or are improvements to existing devices or systems. Inventions, or designs, do not just appear out of thin air. (Khandani, 2005b).

Engineering design is the process of designing a system, component, or process that meets desired requirements. It is a decision-making process (often iterative) that uses basic science, mathematics, and engineering to optimally transform resources to achieve specific goals. The basic elements of the design process include goal and criterion setting, synthesis, analysis, construction, testing, and evaluation. The engineering design component of the curriculum should include most of the following features: developing student creativity, using open-ended problems, developing and using modern design theories and methods, and formulating problem statements and design specifications, production processes, parallel engineering designs, and detailed system descriptions. In addition, it is important to include practical constraints such as economic factors, safety, reliability, aesthetics, ethics, and social impact. (Yousef & Shahin, 2011).

This research aims to analyze the implementation of STEM learning by pre-service science teachers in implementing STEM by adopting the Engineering Design Process (EDP). The implementation of STEM learning by adopting the Engineering Design Process (EDP) can be seen in STEM products and student responses in the learning process.

2. Methods

This qualitative research reveals why the phenomenon appears and how the phenomenon unfolds over time. STEM Project learning-based SDGs is carried out in October – December 2023. The research was carried out in 5 stages of the **Engineering Design Process** as follows in Figure 1.

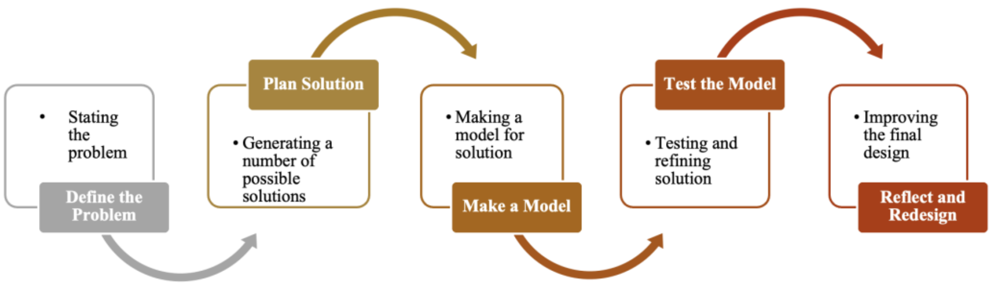

Figure 1. Engineering Design Process

2.1 Participants

The participants are pre-service science teachers in the fifth semester in 2024 who are taking STRM courses at the Islamic Institute of Kudus, Indonesia as many as 44 students. This research used saturation sampling technique. All respondents were asked to make a

STEM project through EDP-based SDGs. Students were also given questionnaires to give responses on learning activities.

2.2 Data

The research data obtained were in the form of STEM development projects with EDP Steps based on SDGs, STEM Products, and responses from prospective teacher students to STEM learning. Student responses were obtained through a closed questionnaire given at the end of the learning stage. The questionnaire used was a checklist questionnaire so that prospective teacher students could choose more than one answer based on the choices provided. The questionnaire consisted of three questions, namely the first about the basis for implementing STEM through EDP. Second, the advantages of implementing STEM through EDP. Third, obstacles in implementing STEM through EDP as table 1.

Table 1: Indicator of STEM Implementation Questionnaire

No	Aspect	Indicator
1	Basic of Implementation STEM by EDP	a. Strengthening relationships between scientific disciplines, namely science, technology, engineering and mathematics b. Demands of 21st century development c. Improving the soft skills of prospective science teacher students d. Develop the ability to solve real problems e. Develop projects that are useful for society f. Preparing students to face the challenges of globalization
2	The Advantages of Implementation STEM by EDP	a. Cognitive, effective and psychomotor abilities develop in balance b. Learning becomes more interesting c. Learning becomes more productive d. Increase student motivation in studying science e. Learning outcomes can take the form of useful products f. Learning that is integrated directly with the real world g. Improve students' ability to design products that are appropriate to the material studied h. Students become more active in the learning process i. Develop higher level thinking abilities
3	The Obstacles of Implementation STEM by EDP	a. Not all material can be easily linked to technology, engineering, and mathematics b. Takes a lot of time c. Difficulty integrating between fields of knowledge in several materials d. Requires a lot of money

The data from the student perception questionnaire was analyzed using the formula

$$P = \frac{F}{N} x \, 100\%$$

P is percentage of answers

F is frequency of answers (the number of respondents who answered with a particular option).

N is total number of respondents

3. Result and Discussion

One of the important findings in this study is the STEM product through the EDP process developed during the learning process. The steps for developing STEM through the engineering design process (EDP) consist of five steps, namely define the problem, plan a solution, make a model, test the model, and reflect and redesign. In addition, student responses were also obtained regarding the benefits and difficulties experienced during the learning process. The results of each product can be explained as follows:

3.1 STEM products developed through EDP

Define the Problem

This stage directs students to define the phenomena or problems that occur. The problems discussed are problems related to the 17 goals in the SDGs, namely No poverty, No hunger, Healthy and Prosperous lives, Quality education, Gender equality, Clean water and adequate sanitation, Clean and affordable energy, Decent work and economic growth, Innovation industry and infrastructure, Reducing inequality, Sustainable cities and settlements, Responsible consumption and production, Addressing climate change, Marine ecosystems, Land ecosystems, Peace, justice, and Resilient institutions, Partnerships to achieve goals. In finding problems, there are several questions that need to be considered as reference materials, including: is the problem real and is the statement accurate?, Is a new solution really needed? What solutions are needed for the problem?, What are the factors (economic, environmental, safety) that regulate the problem? (Khandani, 2005a)

Based on the results of the analysis carried out by prospective science teacher students regarding conditions in the field, several problems were found, including 40.5% of the types of waste that dominate waste generation in Indonesia are household waste, either in the form of food scraps, paper, plastic, or other forms (Annur, 2023). The increase in the amount of waste is also influenced by population growth and changes in consumption patterns. If this is left unchecked, it can affect sustainability in Indonesia because 13.47 million tons of waste has not been managed and has an impact on the environment such as flooding and environmental pollution. The second problem found is related to the number of Indonesian people who is still quite high. Based on FAO data in 2022, as many as 5.9% or 16.2 million people's nutritional needs have not been met (Ula, 2021) which can lead to malnutrition and stunting. Therefore, it is necessary to address this hunger problem.

The third problem related to environmental conditions is also widely found, such as air pollution problems due to waste burning. In 2019, as many as 65% of the community in Pati Regency managed waste by burning it. Waste burning can produce greenhouse gases such as $CO2$, $N2O$, NOx, $NH3$, and organic carbon. Open waste burning will reduce the quality of the surrounding air which can have an impact on public health, such as respiratory tract disorders and eye irritation.

Plan the Solution

Solution development is the second step in the learning process through the engineering design process. In this stage, prospective science teacher students develop solutions to the problems they find by considering the STEM components in them and also the relationship with the SDGs aspects. Prospective science teacher students build solutions based on the problems they each find. In developing this solution, it is necessary to pay attention to several things, including product function analysis, safety, and ergonomics. (Khandani, 2005b). Functional analysis is important for the evaluation and success of product design. Ergonomic aspects are needed to ensure that the product being developed can be used by users, and make it easier for users to interact. Therefore, in creating product solutions, it is also necessary to pay attention to aspects of security and safety for users and the environment. Some solutions provided by students based on SDGs aspects can be explained as in table 2.

Table 2: Problems, solutions and suitability of SDGs themes

No.	Problems	Solution	SDGs Theme
1	Abundant production of kitchen waste, land pollution, causes flooding	SANCA functions as a simple decomposer of organic kitchen waste. In addition, SANCA is equipped with temporary storage for used cooking oil and plastic waste.	1. SDG 3 (Good Health and Well-being)
2	Based on data from the FAO (Food and Drug Organization) in 2022, in Indonesia there are around 5.9% of the total population of Indonesia or 16.2 million people who are hungry	FaN cookies are a source of additional nutrition consisting of 3 ingredients, namely mocaf flour, moringa leaves and jackfruit seeds.	2. SDG 2 (Zero Hunger)
3	Used cooking oil waste is a type of B3 waste (Hazardous and Toxic Materials) which is dangerous if disposed of directly into the environment.	KIT solid and liquid soap used cooking oil	3. SDG 12 (Responsible Consumption and Production)
4	There is an abundance of banana trees but the use of parts of the tree is not optimal.	DEBORA (Banana Tree Trunk Flavor)	4. SDG 2 (Zero Hunger)
5	Optimizing the use of parijoto as a bath soap to meet the community's need for a safe and healthy bath soap.	Parijoto soap	5. SDG 3 (Good Health and Well-being)
7	Agricultural land is decreasing due to the flow of development	Aqualoop (water planting media and fish cultivation)	6. SDG 15 (Life on Land)

Make a Model

After designing a solution to the existing problem, the next step is to develop a product model. The creation of the model refers to the STEM approach, which means that the product developed must contain elements of science, technology, engineering and mathematics. From the results of the development and referring to the SDGs aspect, there are several products produced by student teachers, including:

DEBORA (Debog Pisang rasa). Debora is a product made from banana stems. The purpose of making this product is to reduce the amount of banana stem/stem waste, in addition it can make banana stem/stem more useful and have a selling value. So that from the DEBORA product it can increase the economy of the surrounding community, and provide welfare (Figure 2).

Figure 2. Debora Making Process.

STEM analysis in DEBORA products as follows. First, the science aspect. Banana plants are one of the seed plants that have the following taxonomy:

Kingdom	: Plantae
Subkingdom	: Tracheobiota
Super Division	: Spermatophyta
Division	: Magnoliophyta
Class	: Liliopsida
Sub Class	: Commelinidae
Order	: Zingiberales
Family	: Musaceae
Genus	: Moses
Species	: *Musa paradisiaca L*

Banana plant stems contain nutrients including: water (92.5%), protein (0.35%), carbohydrates (4.4%), phosphorus 135 mg/100 g stem, potassium 213 mg/100 g stem, calcium 122 mg/100 g stem (Lubis et al., 2023). The nutritional content of banana stems has the potential to be developed as processed food products. Chemically, banana stems or banana stems contain flavonoids, tannins and saponins. These flavonoid compounds can be dissolved in water and extracted using 70% alcohol (Imam & Akter, 2011).

Second, the technological aspect. The technology used in the process of making banana stem chips is a pan or frying pan and other frying pans made of metal, aluminium, steel, stainless steel, and Teflon. These materials are chosen because they are good conductors of heat. The third aspect, engineering, namely in the process of making banana stem chips, it needs to be processed in such a way using tools/knives so that chips with the appropriate thickness are obtained. While the fourth aspect, mathematics. This mathematical component is seen in the composition of the ingredients used to make chips such as 150 grams of wheat flour, 100 grams of tapioca flour, 100 grams of crispy seasoned chicken flour, half a teaspoon of salt, and also calculating the total cost required to make the product.

Test the Model

At this stage, a trial of the product that has been developed is carried out to determine the feasibility of the product that has been developed. Trial activities are carried out on several types of respondents according to the product being developed. For example, in the development of the Debora product, the trial was carried out on 20 people consisting of 19 prospective science teacher students and 1 lecturer using 2 flavor variants. The difference in these variants is based on the soaking method used, namely the first variant of banana stems soaked in ice water and the second variant of banana stems soaked using lime water and salt. While the results of the product trial are seen based on texture and taste. The results of the trial are as shown in table 3.

Table 3: Results of the Debora product trial texture specifications.

No	Types of banana stems and manufacturing methods	Crispy	Tough
1	Kepok banana stem with manufacturing method A	20	0
2	Magelang banana stem with manufacturing method A	6	14
3	Magelang banana stem with manufacturing method B	0	20

Description: manufacturing method A (manufacturing method by soaking the stem in ice water) and manufacturing method B (manufacturing method by soaking the stem in water with lime solution).

In addition to the texture, the trial was also conducted to determine the taste of the Debora chips produced. The results are as seen in table 4.

Table 4. Results of the Debora product trial, taste specifications.

No	Types of banana stems and manufacturing methods	Too salty	Fit
1	Kepok banana stem with manufacturing method A	20	0
2	Magelang banana stem with manufacturing method A	0	20
3	Magelang banana stem with manufacturing method B	0	20

From the results of the trial obtained, it can be seen that of the three Debora products given to the audience, there is one product that has a crunchy texture, namely chips from kepok banana stems. It's just that the taste of the kepok banana stem chips is too salty. In addition, it was also found that the chips from Magelang banana stems have the right taste even though the two manufacturing methods are different, it's just that the chips from Magelang banana stems have a tough texture that contains fiber residue when eaten.

Reflect and Redesign

The reflect and redesign stage is the final stage carried out after a trial (test the model). Redesign means redesigning a product that has been made if there is input or evaluation. (S. N. Aini et al., 2024). In this study, based on the input obtained from respondents at the test the model stage, evaluation and improvement were then carried out on the products that had been developed. For example, in the Parijoto soap product (SARITO). From the results of the trial on users, it was found that the shortcomings of the product were that the soap was less foamy and too dry. In the test of using this soap, the first formulation was used with a ratio of Naoh: Aquades: coconut oil: olive oil: parijoto extract, namely 19:115:22:50:25. The results of the soap test the model were less than optimal as expected. Therefore, improvements were made to the soap making formulation with a ratio of Aquades: NAOH: Coconut oil: Olive oil: extract 100: 20: 50: 10 with a ratio of 2:2:1. In using this second formulation soap, it produced more soap foam and was soft on the skin. The difference in results between before and after the formulation change is as in Figure 3.

Figure 3. Differences in SARITO product results before and after formulation improvements.

Responses of prospective teacher students to STEM learning through EDP

In addition to the STEM products that have been produced, this study also conducted a questionnaire to determine students' responses to the use of the STEM learning model through EDP which consists of 3 aspects as follows:

First, the basis for implementing STEM learning through EDP.

This aspect is used to find out students' opinions about the basis for implementing STEM through EDP in learning. Based on the results of the questionnaire, it was obtained that 70.5% of students chose the basis for implementing STEM in learning: the relationship between science, technology, mathematics and technology. While 40.9% of students stated that the basis for implementing STEM through EDP is the demands of 21st century learning and also as an effort to improve students' soft skills. Basically, STEM is an interdisciplinary approach, which in learning combines mathematical and scientific concepts to solve real-world problems. (Margot & Kettler, 2019), focuses on the investigation and application of knowledge, higher-order thinking, and problem-solving skills. (Asilevi et al., 2024). This shows that STEM is in line with the demands of 21st century skills. The results of the student questionnaire on the basic aspects of STEM implementation through EDP are as shown in Figure 4..

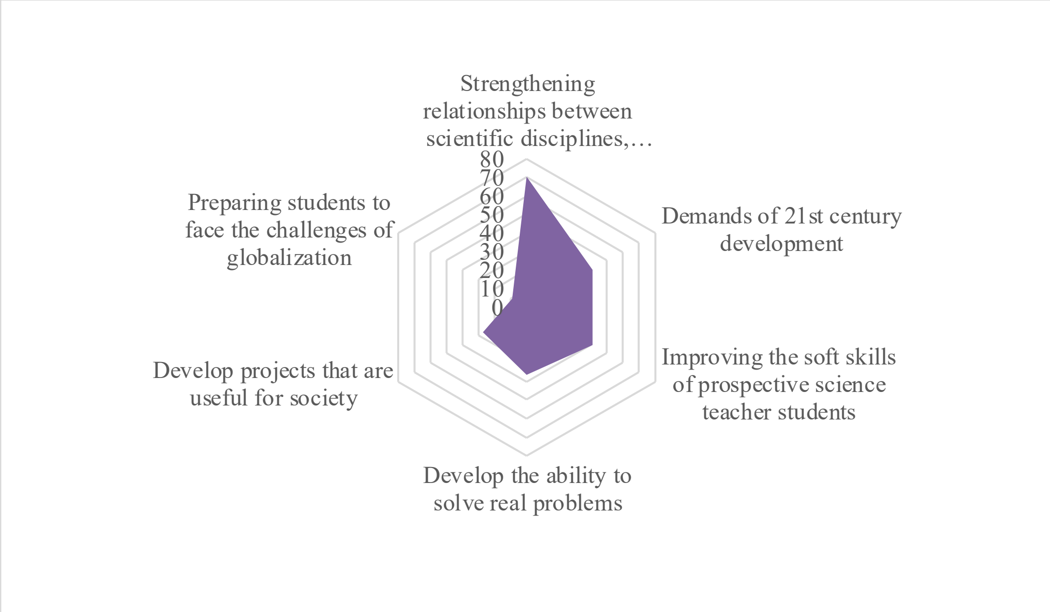

Figure 4. The basis for implementing STEM through EDP in learning

The second aspect asked to students in STEM learning is the benefits that students get from implementing the learning. Based on the results of the questionnaire, it was found that 63.6% of students stated that the benefits of implementing STEM through EDP in learning are that it can balance cognitive, affective and psychomotor abilities. 38.6% of students stated that STEM learning through EDP makes learning more interesting, 34.1% stated that learning is more productive. This is because in STEM learning, students are asked to develop products according to the problems they find in the field. In accordance with the EDP stages after students find problems in the environment, they then offer the right solution in a product that will later be tested in the field. In detail, the benefits obtained from the results of implementing STEM through EDP are as seen in Figure 5.

The benefits obtained by prospective teacher students in implementing STEM learning through EDP are in line with research. Setiawaty (2018) which states that studying subjects in an integrated manner such as in STEM can improve learning outcomes and motivation. In addition, STEM learning can also improve self-efficacy related to STEM, develop positive beliefs especially towards technology and also improve issues related to equality and sustainable development. (Gül et al., 2023). In addition, STEM learning linked to SDGs can also create quality learning. (Afkarina et al., 2024) namely learning that involves intensive student participation (Ardwiyanti et al., 2021) so that it can improve the communication skills of prospective science teacher students, critical thinking skills, science literacy and also other competencies that can help students face global challenges (Maulidia et al., 2019). In addition, the integration of EDP in STEM learning further strengthens students' ability to solve problems because students are required to provide solutions to the problems they encounter (Ulum et al., 2021), Strengthening digital literacy, critical thinking and creativity of prospective teacher students (Lou et al., 2017; Nieveen & Plomp, 2018) .

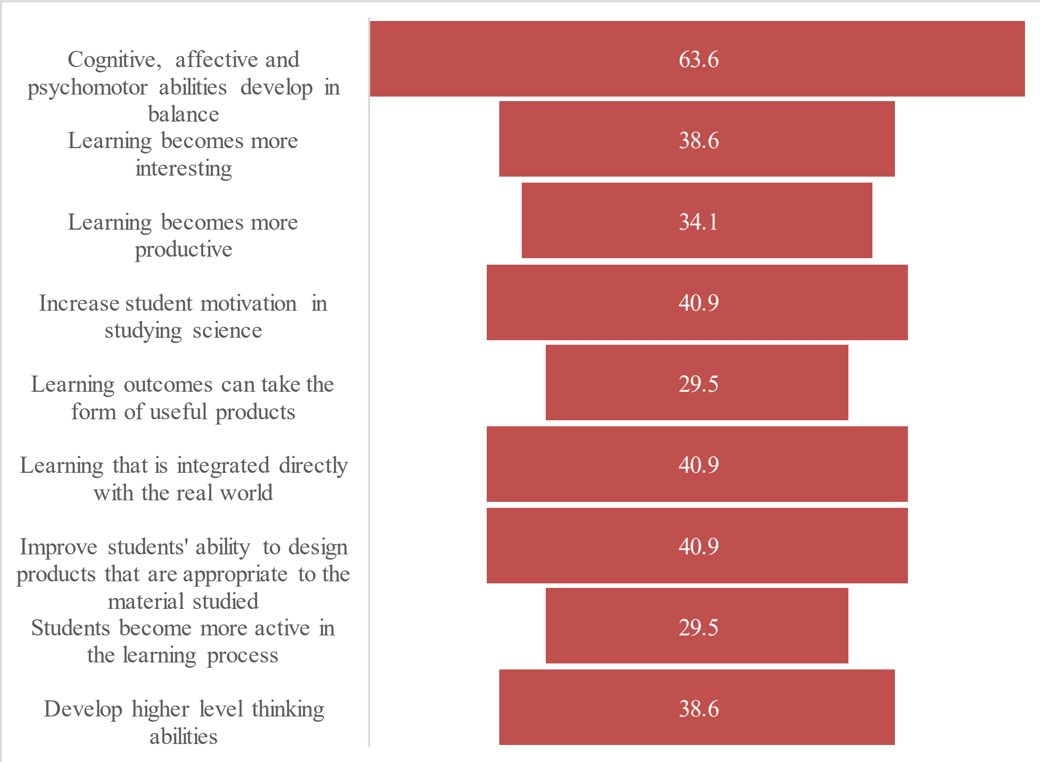

Figure 5. Benefits of implementing STEM through EDP in learning

In general, STEM EDP teaches prospective teacher students to focus on solutions to building prototypes so that they can train critical thinking skills, problem-solving skills and creativity of prospective teacher students (Siew et al., 2016). In addition, with this EDP process, students will be more aware that there are many solutions to the problems they find in the environment related to science. This certainly requires the involvement of prospective teacher students in brainstorming to identify problems and find solutions. In this study, the problems found by prospective teacher students are problems that exist in their environment with reference to the SDGs aspect. The STEM approach is used because this approach emphasizes active learning, problem solving, and is more interesting so that it can easily support the Sustainable Development Goals (SDGs) (Aswirna et al., 2022).

The third aspect regarding the obstacles in implementing STEM learning through EDP was that 61% of students stated that in STEM not all materials can be linked to STEM, 43% stated that STEM learning through EDP takes more time, 50% stated that this learning requires a lot of costs because they have to make products and 32% stated that it is difficult to integrate knowledge with the materials in science (as in Figure 6).

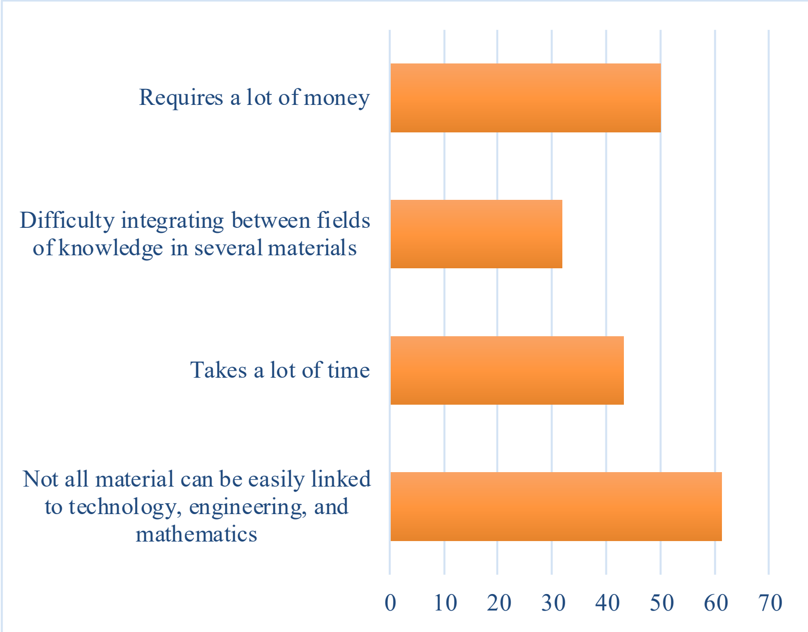

Figure 6. Barriers to implementing STEM through EDP

In the learning process, several students were found to experience obstacles Gül et al (2023) which states that STEM is learning that combines products in an interdisciplinary manner, it takes longer and is difficult to design STEM activities according to existing problems. Therefore, STEM learning requires a classroom environment that is appropriate for group work. (Chen & Lin, 2019).

4. Conclusion

The implementation of STEM learning for pre-service science teacher students through EDP is carried out through 5 stages, namely define the problem, plan a solution, make a model, test the model, and Reflect and Redesign. Based on student responses, it was found that the greatest basis for STEM learning is Strengthening relationships between scientific disciplines, namely science, technology, engineering, and mathematics with a percentage of 70.5%. Meanwhile, the biggest benefit of implementing STEM learning is that cognitive, affective, and psychomotor abilities develop in balance by 63.6%. Meanwhile, the most likely obstacle in implementing STEM learning through EDP is that Not all materials can be easily linked to technology, engineering, and mathematics with a percentage of 61.4%.

5. References

Afkarina, D., Putra, P. D. A., & Lesmono, A. D. (2024). Analisis Keterampilan Scientific Communication Siswa SMA Melalui Pembelajaran STEM-SDGs Pada Materi Pemanasan Global. *JPF (Jurnal Pendidikan Fisika) FKIP UM Metro*, *12*(1), 54–67. https://doi.org/http://dx.doi.org/10.24127/jpf.v12i1.9557

Aini, F. . (2018). Pembelajaran Berbasis STEM dalam Perkuliahan Kalkulus di Perguruan Tinggi. *UJMES*, *03*(2), 104–111.

Aini, S. N., Munahefi, D. N., Pramasdyahsari, A. S., & Setyowati, R. D. (2024). Engineering Design Process STEM : Projek Miniatur Gazebo Joglo. *PRISMA, Prosiding Seminar Nasional Matematika*, 37–43. https://proceeding.unnes.ac.id/prisma

AlAli, R., Alsoud, K., & Athamneh, R. (2023). Towards a Sustainable Future: Evaluating the Ability of STEM-Based Teaching in Achieving Sustainable Development Goals in

Learning. Sustainability. *Sustainability*, *15*(16), 12542. https://doi.org/https://doi.org/10.3390/su151612542
Annur, C. M. (2023). *Timbulan Sampah Di Indonesia Belum Sepenuhnya Terkelola Pada 2022*. 2023. https://databoks.katadata.co.id/datapublish/2023/09/26/timbulan-sampah-di-indonesia-belum- sepenuhnya-terkelola-pada-2022
Ardwiyanti, D., Prasetyo, Z. ., & Wilujeng, I. (2021). STEM research trends in Indonesia: a systematic literature review. *Journal of Science Education Research*, *5*(1), 38–45.
Asilevi, M. N., Nuutinen, S. H., & Kang, J. (2024). Secondary school teachers' interest and self-efficacy in implementing STEM education in the science curriculum. *European Journal of Science and Mathematics Education*, *12*(2), 297–311. https://doi.org/https://doi.org/10.30935/scimath/14383
Aswirna, P., Kiswanda, V., Nurhasnah, N., & Fahmi, R. (2022). Implementation of STEM E-Module with SDGs Principle to Improve Science Literacy and Environment-Friendly Attitudes in Terms of Gender. *Jurnal Tadris Kimiya*, *7*(1). https://doi.org/https://doi.org/10.15575/jtk.v7i1.16599
Chen, C. S., & Lin, J. W. (2019). A practical action research study of the impact of maker-centered STEM-PjBL on a rural middle school in Taiwan. *International Journal of Science and Mathematics Education*, *17*(1), 85–108.
Gül, K. S., Kırmızıgül, A. S., Ateş, H., & Garzón, J. (2023). Advantages and Challenges of STEM Education in K-12: Systematic Review and Research Synthesis. *International Journal of Research in Education and Science*, *9*(2), 283–307. https://doi.org/https://doi.org/10.46328/ijres.3127
Hoban, S., & Delaney, M. (2011). *Beginning Engineering, Science, and Technology*. National Aeronautics and Space Administration.
Imam, M. Z., & Akter, S. (2011). Musa Paradisiaca l. and Musa Sapientum l. : A Phytochemical and Pharmacological Review. *Journal of Applied Pharmaceutical Science*, *1*(5).
Khandani, S. (2005a). *Engineering Design Process: Education Transfer Plan*. http://www.iisme.org/ETPExemplary.cfm
Khandani, S. (2005b). *Engineering Design Process*. Saylor.Org.
Lou, S. J., Chou, Y. C., Shih, R. C., & Chung, C. C. (2017). A study of creativity in CaC2 steamship-derived STEM project-based learning. *Eurasia Journal of Mathematics, Science and Technology Education*, *13*(6), 2387-2404.
Lubis, N. S., Yana, E., Siregar, H., & Wahyuni, M. (2023). Pemanfaatan Pelepah dan Bonggol Pisang (Musa sp.) Menjadi Cemilan untuk Peningkatan Gizi Masyarakat Desa Aman Damai. *Jurnal Kuat : Keuangan Umum Dan Akuntansi Terapan*, *5*(2), 68.
Mahendra, I. W. . (2022). Faktor-Faktor yang mempengaruhi Kemampuan Guru dalam Menyusun Perangkat Pembelajaran Berbasis STEM. *Suluh Pendidikan*, *20*(2), 102–108. https://doi.org/https://doi.org/10.46444/suluh-pendidikan.v20i2.486
Margot, K. C., & Kettler, T. (2019). Teachers' perception of STEM integration and education: A systematic literature review. International Journal of STEM Education. *International Journal of STEM Education*, *6*(2). https://doi.org/https://doi.org/10.1186/s40594-018-0151-2
Maulidia, A., Lesmono, A. D., & Supriadi, B. (2019). Inovasi pembelajaran fisika melalui penerapan model PBL (problem based learning) dengan pendekatan STEM education untuk meningkatkan hasil belajar siswa pada materi elastisitas dan hukum hooke di SMA. *Seminar Nasional Pendidikan Fisika*, 185–190.
Nieveen, N., & Plomp, T. (2018). Curricular and implementation challenges in introducing twenty-first century skills in education. *Springer*, 259–276.
Nusyirwan, D., & Prayetno, E. (2020). Mengajar Engineering Design Process Untuk Memperkenalkan STEM Pada Siswa Madrasah Ibtidaiyah Raudhatul Qur'an. *Warta Pengabdian*, *14*(4), 272. https://doi.org/https://doi.org/10.19184/wrtp.v14i4.19726
Oktapiani, N., & Hamdu, G. (2020). Desain Pembelajaran STEM berdasarkan Kemampuan 4C di Sekolah Dasar. Jurnal Ilmiah Pendidikan Dasar. *Jurnal Ilmiah Pendidikan Dasar*, *7*(2), 99. https://doi.org/https://doi.org/10.30659/pendas.7.2.99-108
Riyanto, R., Syah, I. M., & Muslim, U. B. (2021). *Model STEM dalam Pendidikan "Science, Technology, Engineering and Mathematics."* Penerbit Widina Bhakti Persada.
Setiawaty, S., Fatmi, N., Rahmi, A., Unaida, R., Fakhrah, H. I., Muhammad, I., Mursalin, M., Rohantizani, A., & Sari, R. P. (2018). Science, technology, engineering, and mathematics

(STEM) learning on student's science process skills and science attitudes. *Emerald Reach Proceedings Series*. https://doi.org/https://doi.org/10.1108/978-1-78756-793-1-00036

Siew, N. M., Goh, H., & Sulaiman, F. (2016). Integrating STEM in Engineering Design Process: The Learning Experience of Rural Secondary School Students in Outreach Challenge Program. *Journal of Baltic Science Education*, *15*(4), 477–493.

Ula, A. (2021). Visi Sustainable Development Goals (SDGs) Terhadap Kebijakan Diversifikasi Pangan Lokal Dalam Mengatasi Kelaparan". *Jurnal Sains Edukatika Indonesia*, *3*(2), 58–64. https://jurnal.uns.ac.id/jsei/article/view/70910/39311

Ulum, M. B., Putra, P. D. A., & Nuraini, L. (2021). Identifikasi penggunaan EDP (Engineering Design Process) dalam berpikir engineer siswa SMA melalui Lembar Kerja Siswa (LKS). *Jurnal Riset Dan Kajian Pendidikan Fisika*, *8*(22), 53–63. https://doi.org/DOI: 10.12928/jrkpf.v8i2.20753

Vereinte Nationen. (2018). *The 2030 Agenda and the Sustainable Development Goals: An opportunity for Latin America and the CaribbeanNo Title*. ECLAC.

Yousef, H., & Shahin, T. (2011). *Engineering Design Process (2nd ed.)* (Second Edi). Library.