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Development of environmental sustainability handout based on STEM-PjBL integrated islamic values

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ABSTRACT

To holistically develop students' potential, educators must develop integrative-interdisciplinary teaching materials. Therefore, this research aims to create environmental sustainability material handouts based on Science, Technology, Engineering, and Mathematics and Project Based Learning (STEM-PjBL) integrated with Islamic values suitable for use. The researchers conducted this research from December 2022 to May 2023. This research is research and development. The research and development approach used is the Analysis, Design, Development, Implementation, and Evaluation (ADDIE) development model developed by Dick and Carry. This research shows that the handout developed contains STEM and PjBL components for eco enzyme production project activities. The researchers added Islamic values in the sub-discussion titled Islamic values related to environmental preservation. This sub-discussion explains Al-Qur'an verses and hadiths related to environmental conservation, such as ar-Rum verse 41, al-A'raf verse 56, and hadiths about the virtues of planting trees. The handouts developed are also suitable for use. The validator for the handout gave the feasibility assessment, which determines this feasibility, which received a score of 4.2 and is included in the good category.

Keywords: Environmental sustainability, learning handouts, Project Based Learning, R&D, STEM

INTRODUCTION

Environmental sustainability is an essential thing for society to understand and practice. Based on the observation results, students' awareness of environmental sustainability is still low. Therefore, teaching materials can be a solution to understanding and increasing students' awareness of environmental sustainability.

Environmental sustainability, both water and land, is essential because it is related to the survival of all creatures, so the United Nations includes it in the Sustainable Development Goals. In their research, AlAli et al. (2023) found that the STEM approach can achieve all seventeen sustainable development goals proclaimed by the United Nations. The STEM approach seeks to answer several goals to overcome current and future problems that are also related to environmental sustainability. These goals include the sixth goal (ensuring air), the seventh goal (clean energy), the eleventh goal (safe cities), the twelfth goal (responsible consumption and production), the thirteenth goal (overcoming climate change), the fourteenth goal (conserving marine resources), and the fifteenth goal (protecting wild animals). These goals represent the current and future problems a STEM approach aims to solve (AlAli et al., 2023).

Baran et al. (2021) found that applying PjBL-STEM was able to develop students' environmental sensitivity, which was measured quantitatively and qualitatively. The underlying reason for this is that the projects used in STEM learning use real-life problems or can be called social-scientific subjects so that they can increase students' awareness as responsible citizens (Baran et al., 2021; Connors-Kellgren et al., 2016; Cooper & Heaverlo, 2013; Lou et al., 2017).

Teaching materials significantly influence learning goals and students' academic achievements because they encompass the competencies teachers and students will

complete and use as references in the learning process (Aisyah et al., 2020; Prabowo et al., 2019). In other words, teaching materials convey the teacher's vision to students in the process of learning so that what is expected by the teacher can be conveyed and mastered or put into practice by students.

According to Regulation issued by the Minister of Education and Culture of the Republic of Indonesia Number 37 of 2018 on Core Competencies and Basic Competencies for Lessons in the 2013 Curriculum in Basic Education and Secondary Education, Basic Science Competency 3.8 in elementary schools aims to clarify the significance of efforts to balance and conserve natural resources in the environment. Additionally, Basic Competency 4.8 aims for students to engage in activities to conserve natural resources with others in their environment, specifically in Grade IV of MI/SD (Mendikbud, 2018). We expect teachers to develop these competencies through the learning process and by creating contextual teaching materials that are meaningful, easily understandable, and valued by students. These expectations align with the provisions of Minister of National Education regulations Number 16 of 2007 concerning Academic Qualification Standards and Teacher Competencies, which requires professional teachers to possess a mastery of subject matter, conceptual structures, and scientific thinking relevant to their subjects, as well as proficiency in teaching competency standards and basic competencies while fostering creativity in developing instructional materials.

STEM is an acronym for Science, Technology, Engineering and Mathematics. Through STEM learning, students are trained to apply scientific processes and attitudes to solve everyday problems (Jatmika et al., 2020). Recently, experts have further developed STEM into STEAM by adding the letter A, which stands for Art, which means art intends to make learning more exciting and creative (Rahmadana & Agnesa, 2022). Meanwhile, project-based learning (PjBL), according to Smith and Dodds (1997), is learning that utilizes real-world work tasks to achieve specific work goals, both for individuals and groups (Robert J. DeFillippi, 2001). Project-based learning influences student learning outcomes because it invites students to learn constructively and meaningfully to apply the material they have learned. It simplifies students' process of tackling test questions (Aisyah & Rosnita, 2021).

Religion provides beliefs in the form of spirituality to humans, which underlies their behaviour and actions in changing the natural and social environment (Ritzer, 1980). Therefore, it is essential to integrate religious values into every learning, not only in religious learning, because religion covers many dimensions of human life, both social and natural. Islam is a religion that is concerned with preserving the natural environment. For example, Allah SWT forbids humans from causing damage to the earth (Q.S. Al-A'raf: 56), and in the hadith, Allah SWT will reward Muslims who plant trees in alms.

Susilowati (2017) carried out relevant research. This research indicates that integrating science teaching materials with Islamic values can enhance religious attitudes, foster positive attitudes towards science, and improve student learning achievements. Utami & Darmana (2020) conducted another relevant research. The research findings demonstrate that teaching materials based on the SETS (Science, Environment, Technology, and Society) Integrated Islamic Values approach effectively enhance student learning outcomes. Contrasting with the STEM approach, the SETS approach emphasizes comprehending the interplay between science, technology, environment, and societal implications. In contrast, STEM focuses more on cultivating technical and analytical skills through interdisciplinary learning.

Jatmika et al. (2020) have also conducted relevant research. The research concluded that integrating Project-based Learning (PjBL) and STEM models enhances process skills across all

indicators. Afriana et al. (2016) conducted further relevant research. The research results indicate that integrating STEM and Project-based Learning (PjBL) can enhance scientific literacy skills. Hamid et al., (2017) carried out subsequent relevant research. The study's findings suggest that innovative use of social media can influence environmentally friendly behaviour. Nurulloh (2019) has also conducted relevant research. The research findings conclude that one effective method of cultivating environmental awareness in Islamic education involves internalizing environmentally rooted religious values within educational institutions.

Rokhim et al. (2020) have conducted another relevant research. This research has developed flipbook teaching materials on redox and electrochemistry using the STEM-PjBL approach, complemented by feasible learning videos. Agung et al. (2022) have also conducted research that resulted in a science e-module utilizing a STEM-PjBL model focused on character education, demonstrating feasibility and proven effectiveness in enhancing student learning outcomes. Triastuti (2020) conducted research concluding that employing the STEM-PjBL learning model in making ice cream can positively impact creative thinking and entrepreneurial skills. Fajria et al. (2022) have developed a Project-based Learning (PjBL) integrated STEM model mathematics learning tool, which has been shown to enhance creative thinking abilities. Suryani (2024) conducted literature research that concludes using teaching materials integrated with EtnoSTEM in the PjBL model is an innovative method to cultivate environmentally caring character traits.

The description of the background and the results of observations, which show that students' awareness of environmental sustainability is still low and that there are no teaching materials with the theme in question, are the reasons for the author to conduct this research. Therefore, this research aims to develop environmental sustainability teaching materials based on Science, Technology, Engineering, and Mathematics and Project Based Learning (STEM-PjBL) integrated with Islamic values deemed suitable for use.

METHOD

This research adopts a research and development approach utilizing the Analysis, Design, Development, Implementation, and Evaluation (ADDIE) model developed by Dick and Carey. ADDIE is a product development model. Researchers utilize this concept to create performance-based learning. The educational philosophy underlying the implementation of ADDIE is student-centred, innovative, authentic and inspiring learning (Branch, 2009). Researchers test the products developed as teaching materials using a quantitative approach on specific samples to test hypotheses and determine their effectiveness (Sugiyono, 2019).

The research stages follow the steps of the ADDIE development model, which consists of five stages (Mulyatiningsih, 2014). The initial stage of research conducted during the Analysis phase involves performing a needs analysis to identify issues, determine suitable solutions, and assess student competencies. In the Design stage, the researchers prepare the framework for teaching materials, a needs map, and a validation sheet for the teaching materials. In the development stage, the researchers develop teaching materials and validate them with experts following the chosen learning approach. At the Implementation stage, the researchers test teaching materials, conduct assessments, and have students fill out research data instruments. At the evaluation stage, errors that occur during learning are analyzed and corrected.

The handout validation results include scores and notes or feedback. The researchers averaged the validation scores using the following formula.

$$\text{Mean validation score } (\bar{x}) = \frac{\sum X_i}{n}$$

$\bar{x}$ = mean validation score
Xi = score given by the i-th validator
n = number of validators

The researchers then converted the average scores resulting from validator product assessments into five categories, according to Widoyoko (2016). Widoyoko (2016) determines category intervals using the formula in Table 1.

Table 1. Category interval formula

Score Intervals	Category
$\bar{X}_i + 1.8 \times sb_i < X$	Excellent
$\bar{X}_i + 0.6 \times sb_i < X \leq \bar{X}_i + 1.8 \times sb_i$	Good
$\bar{X}_i - 0.6 \times sb_i < X \leq \bar{X}_i + 0.6 \times sb_i$	Fair
$\bar{X}_i - 1.8 \times sb_i < X \leq \bar{X}_i - 0.6 \times sb_i$	Poor
$X \leq \bar{X}_i - 1.8 \times sb_i$	Not Good

Information:
$\bar{X}_i$ (ideal average) = $\frac{1}{2}$ (ideal maximum score + ideal minimum score)
sb_i (ideal standard deviation) = $\frac{1}{6}$ (ideal maximum score - ideal minimum score)
X = empirical score

Table 2 depicts the classification of learning device and assessment device evaluation scores. The researchers consider a product worthy if it achieves a minimum score of 3.5 in the "good" category.

Table 2. Conversion of the product validation score by the validator

Mark	Score Intervals	Category
A	$4.2 < X$	Excellent
B	$3.4 < X \leq 4.2$	Good
C	$2.6 < X \leq 3.4$	Fair
D	$1.8 < X \leq 2.6$	Poor
E	$X \leq 1.8$	Not Good

RESULTS AND DISCUSSION

Analysis

a. Needs Analysis

The needs analysis begins by collecting data by observation and interviews related to awareness of environmental sustainability and the availability of teaching materials on environmental sustainability. The researchers interpret the data obtained and develop recommendations by planning product development to meet the received data needs. The obtained data shows that students' level of environmental sustainability awareness remains low. Students not accustomed to throwing rubbish in the trash bin have low enthusiasm and consideration of environmental issues, pollution and environmental conservation.

STEM-PjBL-based teaching materials integrated with Islamic values in environmental sustainability material are also unavailable. Based on the findings of this needs analysis, researchers believe it's crucial to create STEM-PjBL-based handouts that integrate Islamic values and are practical.

Handouts are printed materials teachers prepare to enrich students' knowledge (Pingge et al., 2021). The author generally takes the handout contents from several library sources relevant to the material taught, namely basic competencies and primary material. The steps for compiling a handout are: 1). conducting curriculum analysis; 2). determine the title; 3). collect references; 4). write handouts in clear and concise sentences; 5). evaluate the handouts that have been prepared; 6). improving handouts; 7). utilize various learning sources that enrich material, such as books, research articles, newspapers, magazines, and so on (Depdiknas, 2008). Handout teaching materials contain several components: material descriptions, charts, assignments, and prepared reference materials (Kurniasih & Sari, 2014).

According to Prastowo (2015), the principles for preparing handouts are the same as those for teaching materials: relevance, consistency, and coverage. The principle of relevance is a principle that requires the content of the material to follow the competency standards and basic competencies to be achieved. The principle of consistency means that all material written represents the competency standards and basic competencies that will be accomplished. The principle of sufficiency means that teaching materials are guaranteed to help students master basic competencies (Prastowo, 2015). The benefits of using handouts in learning include increasing students' interest in learning, making students more active in learning, increasing students' understanding of concepts, improving students' learning outcomes, and reducing the use of too

many verbal words in the material presented (Raharjo, 2016; Stevany, 2017).

b. Curriculum Analysis

Researchers carry out curriculum analysis by paying attention to the suitability of the content of the teaching materials to be created with the curriculum implemented in the school, namely the 2013 curriculum. Based on the analysis of the 2013 curriculum content, environmental sustainability topics in elementary schools are taught in Grade IV, focusing on Basic Knowledge Competency 3.8, which involves explaining the importance of maintaining and preserving natural resources in the environment, and Basic Competency Skill 4.8, which includes participating in activities to conserve natural resources with others in the environment. The contents of the developed handouts are tailored based on the foundational competencies identified in the curriculum analysis.

Design

Based on the findings from the previous analysis, the following design stage involves identifying the necessary elements for the handout, selecting references for developing the material in the handout, and outlining the validation instruments for the handout under development. The following are the outcomes of the planning stages that have been completed.

a. Handout

Figure 1 shows the list of contents of the designed handout.

LIST OF CONTENTS
A. Instructions for Use
B. Learning Objectives
C. Content Structure Analysis
D. Procedural Analysis
E. Concept Map
F. Material Description
G. Assignments (Projects)
H. Practice Questions
I. References

Figure 1. Handout Table of Contents' Draft

Table 3 shows the design of the STEM content structure in the handout.

Table 3. STEM content structure design.

Science	Technology
1. Explain the principles of environmental sustainability 2. Explain the benefits of environmental conservation	1. Benefits from the application of biotechnology products 2. Access information on the internet
Engineering	**Mathematics**
1. Designing the manufacture of fermented products 2. Inventory of the tools and materials needed	1. Calculate the volume of the container 2. Calculate the ratio of molasses: organic matter: water 3. Calculate the length of the fermentation process

Table 4. Shows the project-based learning content structure's design.

No	Stages of Project-Based Learning	Project-Based Learning Stage in Teaching Materials
1.	Basic question direction	There are contextual questions that are appropriate to the learning material. Students can only answer questions by investigating and creating a project.
2.	Designing project planning	Students, together with lecturers, design the project that will be implemented.
3.	Determine the schedule	Students and lecturers make an agreement on the time to work on the project.
4.	Monitor the progress of student projects.	Prepare a monitoring table containing a statement of the progress of the project carried out by students, which will be used as material for the lecturer to assess.
5.	Testing against results (creation of intermediate reports)	Students make intermediate reports related to investigative projects' results while making products.
6.	Evaluation of experience	At the evaluation stage, the teacher asks students to present the results of the projects they have worked on. Students and lecturers held discussions

		together to find out the advantages and disadvantages of implementing the projects that had been carried out. The evaluation results can be used as a reference for further improvement of the learning process. At this stage, the researchers carry out the process of making conclusions and reflections.
7.	Making final report	Students make a final project report by completing the intermediate report with the results of eco-enzyme harvesting.

b. Handout Assessment Sheet

The researchers prepare the Handout assessment sheet by considering the assessment aspects of teaching materials, namely aspects of suitability of content, presentation, graphics/ appearance, suitability of language, suitability with STEM and PjBL approaches, and suitability of integrated Islamic religious values.

Development

The development stage encompasses implementing the product design and research instruments designed during the prior stages. These tools include handouts and assessment sheets for validators.

The handouts developed are then validated or assessed for suitability by experts (validators). The scores given on the handout by the validator are then converted into five scale categories as presented in Table 2, namely categories A (excellent), B (good), C (fair), D (poor), and E (not good). The validator assigns a maximum score of 5 and a minimum score of 1 for each assessment item. The assessment results from the validator yielded an average score of 4.2, corresponding to a letter grade of B and falling into the "good" category. Researchers concluded that the initial handout product validated by an expert was suitable for testing, depending on prior revisions. A summary of the expert validation results for the handout's feasibility after conversion is detailed in Table 5 and illustrated in Figure 2.

Table 5. Score of handout validation results by validator

Expert I	Expert II	Expert III	Expert IV	Expert V	Average	Category
4,2	4,2	3,8	4,4	4,4	4,2	Good

The average difference in assessments by the validator for the handouts is minimal. The researchers assess the level of agreement by calculating the difference in assessment scores provided by the validator. The magnitude of this difference serves as a benchmark for evaluating the agreement on the feasibility of the device. A difference in assessment of ≥ 1 indicates a low level of agreement on feasibility, while a difference of ≤ 1 indicates a high level of agreement. With a difference in assessment by the validator of 0.12, it can be concluded that there is a "high" level of agreement on the feasibility of the handout as assessed by the validator.

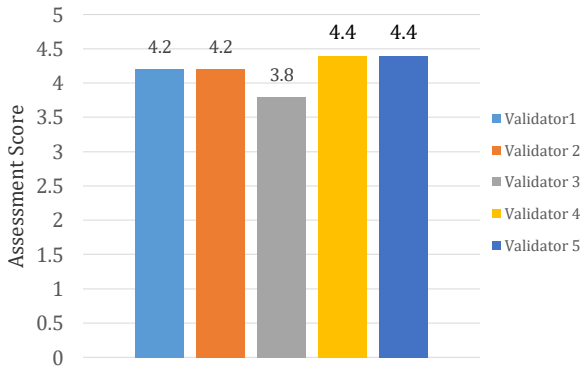

Figure 2. Handout assessment bar chart by validator.

The validator's notes and input on the handout became material for the final revision by the researchers before implementation. This revision aims to improve the handout and align with development objectives. Table 6 presents the validator's notes and feedback on the research instrument.

Table 6. Assessment of Research Instruments

No.	Instrument	Notes
1.	Science Process Skills Questions	a. Suggestions for essay process skills questions; b. Questions number 1-20 tend to measure knowledge. Suggestion. If measuring

		observations, it is better to provide pictures/ data; c. The questions are in the form of respondent choice data. It's better to provide data that is easy to read immediately; d. Questions number 21 and above tend to be good.
2.	Environmental Sustainability Awareness Questionnaire	a. In general, it is good; b. Suggestions are more contextualized other than throwing away rubbish; c. The indicators do not match. Is indicator number 1 reversed with number 3; d. All statements are positive, and it is good to vary some positive and some negative so that students can take the questionnaire seriously.

Implementation

The implementation stage involves applying the research products and instruments created. At this stage, students fill out a questionnaire sheet, which researchers use to measure student responses to the handout, the learning process, and the practicality of the handout being developed so that only students can fill out the questionnaire sheet. At this stage, students fill out a questionnaire sheet to measure student responses to the handout, the learning process, and the practicality of the handout being developed so that only students can fill out this questionnaire sheet. Data from student response questionnaires determine the practicality of the developed handout and its acceptance in the learning process. The results from these questionnaires can be found in Table 7.

Table 7. Results from completing the student response questionnaire.

Devices	Score	Category
Handout	4.18	Good
Learning process	4.27	Excellent

The results from student questionnaires regarding the developed handouts and the learning process indicate an "excellent" rating, suggesting positive student responses. Based on these findings, the researchers concluded that the handouts developed that integrated STEM-PjBL with Islamic values were practical and well accepted.

Students' positive responses to the developed handouts indicate they are highly motivated to use the STEM-PjBL-based biology handouts integrated with Islamic Values. According to Sardiman (2014), strong motivation among students enhances their ability to grasp lessons effectively and fosters positive attitudes toward learning. This motivation and positive attitude will most likely produce good learning outcomes, and this is supported by the research findings of Dimyati and Mudjiono, who state that individuals with high motivation tend to achieve better learning outcomes (Budiariawan, 2019).

Evaluation

At this stage, the researchers assessed the handouts developed and the learning process that had been implemented. The researchers base this assessment on input from student response questionnaires and researchers' observations. This assessment aims to enhance the developed handouts and the learning process to align better with developmental objectives. Student assessment outcomes, encompassing corrections, notes, and feedback, are detailed in Table 8.

Table 8. Students' suggestions.

No.	Notes/ Input/ Handout Correction	No.	Learning Process Notes/Suggestion
1.	The image printing is a bit blurry.	1.	The explanation is relatively flat but understandable.
2.	Instructions for using the handout are too concise.		

The novelty of the findings in this research lies in developing teaching materials that integrate STEM and Project Based Learning models with Islamic values in environmental

sustainability material, which other previous research has not carried out. The researchers expect the application of the teaching materials from this research to be more comprehensive in developing students' cognitive, affective, psychomotor, and spiritual abilities than other research. This expectation is based on the fact that the handout produced from this research is integrative-interdisciplinary, involving learning models and religious values in environmental sustainability material, which has not been found in other research.

CONCLUSION

The researchers drew the following conclusions based on the research findings and discussions. The researchers developed a handout and applied STEM and PjBL components in the eco enzyme production project activities in the handout. Related to Islamic values, the researchers added Islamic values in the sub-discussion titled Islamic values related to environmental preservation. This sub-discussion explains verses from the Qur'an and hadiths related to environmental conservation, such as ar-Rum verse 41, al-A'raf verse 56, and hadiths about the virtues of planting trees. STEM-PjBL-based handouts integrated with Islamic values developed are feasible for use. Feasibility is demonstrated by the assessment results from expert validators, who scored 4.2 in the "good" category, indicating suitability for use. Additionally, students' responses to the developed handouts scored 4.18, falling within the "good" category.

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