Development of Student Activity Sheets Based on Educational Principles for Sustainable Development in Mathematics Learning

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Abstract. This research and development study aims to develop a Learning Worksheet (referred to as *Lembar Kerja Peserta Didik* or LKPD) based on educational principles for sustainable development in mathematics learning. This research was conducted to determine the level of validity, practicality, and effectiveness of the LKPD developed. This research adopts a 4-D model created by Thiagarajan, consisting of four stages: define, design, develop, and dissemination. The LKPD was designed using both digital applications and print media. The validity of the LKPD was evaluated by validators by using an assessment sheet, obtained a score of 4.5 out of 5.0, which falls under the category of very valid. Then, the practicality of the LKPD based on the principles of education for sustainable development is assessed by using both teacher and student response questionnaire. The teacher response rate was 96.92%, categorized as very high practicality. The score of the student response questionnaire was 88.8%, also classified as very high practicality. Furthermore, the effectiveness of LKPD based on the principles of education for sustainable development is tested by pretest and post-test. Based on the analysis of students' pretest and post-test scores, the average N-Gain score is 0.76032, indicating a high level of effectiveness.

Keywords: LKPD, Sustainable development, Statistics, Mathematics Learning, Media.

1 Introduction

Sustainable development is a concept which is explicitly address environmental, economic, and social perspective. The goals include ending poverty, ensuring environmental sustainability, and promoting peace and justice, all of which illustrate the comprehensive nature of sustainable development [1]. This concept is familiar; it has been proven in the Preamble to the Constitution of the Republic of Indonesia in 1945 and Law Number 20 of 2003 concerning the National Education System. One of the ways to achieve sustainable development in the realm of education is the introduction of *Education for Sustainable Development* (ESD) as one of the principles in education. ESD

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principle is a learning process based on noble ideals and fundamental principles of sustainability, with attention focused on all types and levels of learning to provide quality education and develop sustainable human development. The implementation of the ESD is based on ideas relevant to local interests and local cultures so that it will have a unique approach worldwide [2].

Another way to support ESD-based learning, aside from teacher, is through the use of teaching materials. According to the Ministry of National Education, as cited by Khakam [3], teaching materials are organized resources, either written or unwritten, designed to foster a learning environment that encourages student. The presence of teaching materials can help students understand the material. Teaching materials are designed to reduce cognitive load by presenting information in a structured, step-by-step format [4]. Furthermore, teaching materials play a vital role in enhancing student engagement, accessibility, and learning outcomes ([5], [6])

In addition, mathematics is also related to the achievement of ESD. Mathematics plays a vital role in fostering sustainable development by providing the tools necessary for solving complex problems related to environmental, social, and economic challenges. Galkin, Saraev, and Tyrin [7] states that the application of mathematical models helps us understand and predict the behavior of various problems, aiding in decision-making that aligns with the Sustainable Development Goals (SDGs)**.** The integration of sustainability concepts into mathematics education can help students see the relevance of mathematical skills in real-world applications. By teaching students how mathematics can be used to solve sustainability-related problems, educators can inspire future generations to actively participate in building a sustainable future. This approach is aligned with UNESCO's goals for promoting education for sustainable development; Bacon then supported that mathematics can be associated with social problems that will enable students to analyze and criticize these things with their knowledge [8].

This research aims to examine the role of mathematics in achieving the goals of ESD, especially in statistical materials. However, the results of the observations made by the author on the condition of the learning process at SMP Negeri 17 Bulukumba only used the 2013 revised 2018 curriculum book issued by the Ministry of Education and Culture as teaching materials without other teaching materials as companions. Effective teaching materials can certainly attract students' interest in learning and will then impact increased learning outcomes [9]. Belawati [10] and Laila [11] both highlight the crucial role of teaching materials in enhancing the learning process for both teachers and students, whether the instruction takes place in a classroom setting, individually, or in group-based activities. Based on these problems, through this research, the researcher developed a teaching material on statistical material based on the ESD principle.

2 Research Method

This research is Research and Development (R&D), which is a research method used to produce certain products and test the effectiveness of the products produced [12]. The stages in this study include the define stage, design stage, develop stage and dissemination stage. The products produced in this study are worksheets (LKPD) teaching

materials based on the ESD principle in grade VIII statistics material, at SMP Negeri 17 Bulukumba in the even semester of the 2023/2024 school year. The participants of this study were 24 students of class VIII A, 1 mathematics teacher, 2 lecturers majoring in mathematics. Supporting tools are also needed to develop teaching materials, including learning outcome tests, validity tests, and response questionnaires.

The data analysis in this study consists of validity data analysis, practicality data analysis, and effectiveness data analysis. The analysis of LKPD data based on the ESD principle was obtained from the data from the results of the validator evaluation using the following assessment criteria.

Table 1. Guidelines for Assessing Validity Data Questionnaires

Category	Information
$4.5 \leq M \leq 5.0$	Highly valid
$3.5 \leq M \leq 4.5$	Valid
$2.5\ M \leq \leq 3.5$	Quite Valid
$1.5 \leq M \leq 2.5$	Less Valid
$M \leq 1{,}5$	Invalid

The LKPD practicality data was analyzed using teacher and students' response questionnaire data. The assessment of the teacher and student response questionnaire uses the Likert scale, which is in the form of giving a statement, which will then be given a check mark on the answer with five alternative choices. In determining the answer value of the response questionnaire, the questionnaire assessment guidelines, according to Riduwan and Sunarto [13], can be seen in Table 2.

Table 2. Guidelines for Assessing Practicality Data Questionnaires

Choice of Answer	Value for grain	
	Positive	Negative
Excellent	5	1
Good	4	2
Pretty good	3	3
Not good	2	4
Bad	1	5

To calculate the percentage value of responses using the formula according to Riduwan and Sunarto [13], namely

$$\text{Percentage} = \frac{\text{total score}}{\text{maximum score}} \times 100\%$$

Then, the percentage results obtained are adjusted to the practicality assessment category from Centaury [14] as shown in the Table 3

Table 3. Categories of Practicality Assessment

Interval	Criterion
81 – 100 %	Very High
61 – 80 %	High
41 – 60 %	Moderate
21 – 40 %	Low
0 – 20 %	Very Low

Meanwhile, the N-Gain test was used to analyze the LKPD effectiveness data. The *N-Gain* test is used to determine the magnitude of improvement in students' thinking skills before and after being given treatment. The *N-Gain* test uses a formula adapted from Hake [15].

$$\text{N- Gain} = \frac{\text{Xpost} - \text{Xpre}}{\text{Xmax} - \text{Xpre}} \quad (2)$$

The known N-Gain results divided based on *the N-Gain* criteria. *The N-Gain* criteria are described in Table 4

Table 4. Criteria *N-Gain*

N-Gain	Criterion
N-Gain ≤ 0.3	Low
$0.3 \leq$ *N-Gain* ≤ 0.7	Medium
N-Gain > 0.7	High

3 Result and Discussion

The stages of the 4-D development model adopted by Thiagarajan et al. [16] consist of four stages: *Define*, *Design*, *Develop*, and *Dissemination*.

3.1 A Define Stage

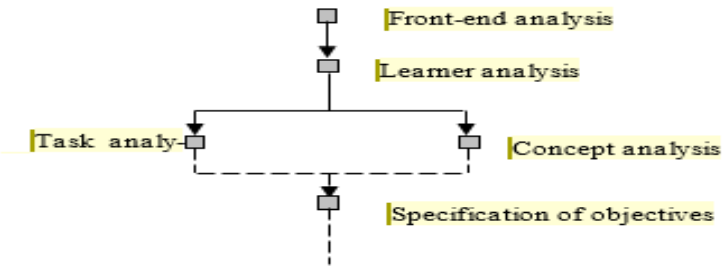

Fig. 1. Define Stage

At this stage, the researcher conducts initial and final analysis through initial observation activities and direct interviews. Analyze student needs, curriculum, and context to understand the requirements for Student Activity Sheets (LKPD) based on educational principles for sustainable development in mathematics.

Front-end Analysis: At this stage, the researcher observes the learning process in the classroom. It was found that the lack of student interest in the learning process was due to the use of teaching media that only focused on package books provided by the school and the use of questions that students thought could not be used in daily life. Based on the observations and interviews, the researcher revealed a solution that could help students express these problems, namely by developing teaching materials in the form of LKPD. The LKPD that students need in the learning process is an LKPD that is easy to understand and interesting. It can make students interested and active in the learning process and help students understand concepts to be implemented in daily life.

Learner Analysis: In this case, the researcher found that the characteristics of students vary. This is seen from the interests, talents, views on the subject, environment, and background of the students. This also affects the understanding and interest of students in the learning process. According to Fauziyah and Hamdu [17], in realizing students' activeness in certain subjects, a learning tool is needed to support students to be active. One of them is LKPD, which contains problems that are common or common in daily life.

Task Analysis: the learning content chosen by the researcher based on the analysis conducted at SMP Negeri 17 Bulukumba in grade VIII include basic competencies and learning objectives, namely the 2013 curriculum.

Concept Analysis: at this stage, the content of the learning unit that the researcher has analyzed is then systematically included in the LKPD.

Specification of Objectives: At this stage, the researcher analyzed learning objectives. The researcher formulated the learning objectives described as being included in the process of developing material in LKPD based on the principles of education for sustainable development.

3.2 Design

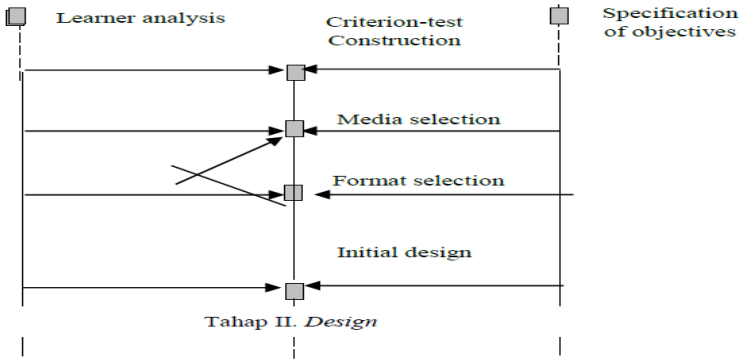

Fig. 2. Design Stage

Select appropriate media and format. Design engaging, user-friendly LKPD that incorporate educational principles for sustainable development in mathematics learning.

Preparation of the Test: preparing the test and development instrument includes the following steps: 1) Summarizing statistical materials that are in accordance with the objectives of learning, as well as compiling materials that will be included in the LKPD, 2) Creating pretest-posttest questions that contain essay questions, 3) Making a questionnaire of student and teacher responses to the LKPD to be assessed, 4) Create a validation sheet for expert lecturers to assess the LKPD to be developed, and pretest-posttest validation sheets

Media Selection: At this stage, the researcher selects the media to be used in the LKPD based on previous findings. Print media is selected due to its simplicity and ease of use. Additionally, the limited availability of electronic devices in the classroom supports the choice of print format, ensuring the LKPD can be effectively utilized during classroom learning.

Format Selection: At this stage, the media format used by the author is adjusted to the media that has been selected previously. For developing this LKPD, the researcher used the Canva application to create the layout.

Initial Design of LKPD, at the initial design stage of LKPD products based on the principles of education for sustainable development, can be seen in the figure below

Fig. 3. Cover of LKPD

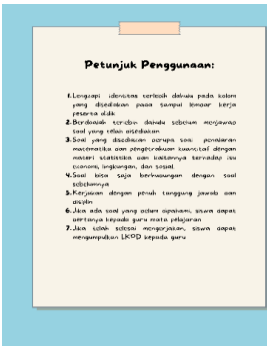

Fig. 4. Instructions for the use of LKPD

Fig. 5. Basic questions about statistics

Fig. 6. Introduction to the basics of ESD

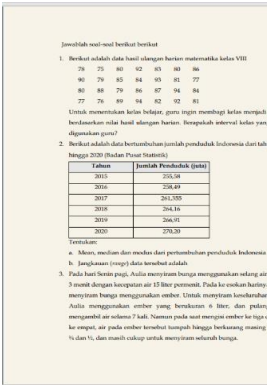

Fig. 7. Statistics Questions with ESD

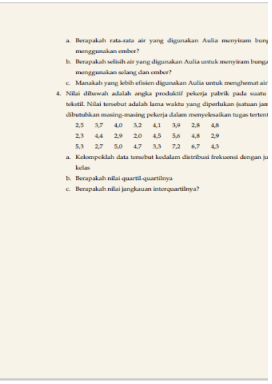

Fig. 8. Statistics Questions with ESD

Consideration when making LKPD include (1) using good and attractive colors so that students are happy to learn using LKPD [18], (2) choosing the correct language, sentences that are not too long, not complicated, simple and positive [19], (3) using image media to increase students' motivation in the learning process [20], (4) using several sentences that will require students to think critically [21].

Furthermore, In the context of mathematics education and education for sustainability, These activity sheets are designed to deliver high impact on the students life, even small changes made by students can make a significant difference. For example, students might adopt practices to reduce water, fuel, and electricity usage, demonstrating their commitment to sustainable living. Through mathematical thinking and strategies, they can analyze real-life problems, develop practical solutions, and confidently present their findings in both oral and written formats. Moreover, by sharing their knowledge with others, they contribute to a broader awareness of sustainability issues. Appreciating mathematics in this context involves recognizing its relevance to real-world challenges. By contextualizing mathematical concepts, students can see how mathematics is represented in the physical aspects of our world, such as visual patterns and data. This not only deepens their understanding but also highlights the role of mathematics in fostering sustainable practices.

3.3 Develop Stage

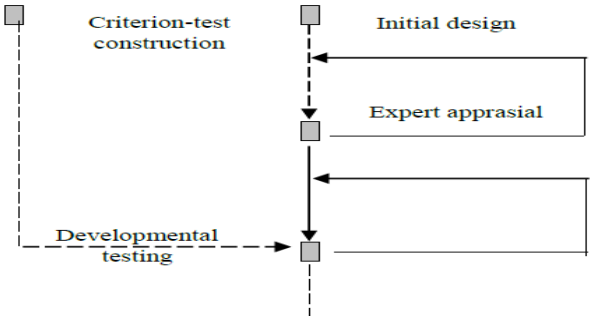

Fig. 9. Develop Stage

Validate and test the LKPD with experts and students. Revise based on feedback to ensure clarity, practicality, and effectiveness in achieving learning outcomes.

Expert Validation

Pre-test and Post-test *Validation*: Research instruments that are made and validated in the form of pre-test and post-test related to the material. This validation is carried out to determine the feasibility of the questions before use. Two expert lecturers carried out this validation. The results of the pre-test and post-test validation can be seen in Table5.

Table 5. Pre-test *and* Post-test *Validation Results*

No.	Assessed Aspects	Value	Information
1.	Blueprint identity components	4	Valid
2.	Components of the Blueprint matrix	4	Valid
3.	Blueprint content	4	Valid
4.	Identity of the test device	4	Valid
	Rata-rata total	4	Valid

The results of the pre-test and post-test validation are in the valid category

LKPD Product Validation: This validation aims to determine the level of feasibility of the developed product based on suggestions from validators. Validation and assessment are conducted by presenting the LKPD products to validators. Two validators carry out validation; the results of the validation can be seen in Table 6

Table 6. LKPD Validation Results by Expert Lecturers

No.	Validator	Grade Point Average	Information
1.	Validator 1	4,5	Highly Valid
2.	Validator 2	4,5	Highly Valid
	Rata-rata Total	4,5	Highly Valid

Product Trial

The practicality test, assessed through the teacher response questionnaire, indicated high scores across all evaluated aspects. Specifically, content feasibility scored 97.76%, language feasibility 93.3%, design feasibility 100%, and usefulness feasibility 100%. Overall, the average score for the LKPD practicality test based on teacher responses was 96.92%, which falls into the "practical" category. From the student response questionnaire, the content feasibility scored 80.41%, the language aspect 93.8%, design aspect 91.94%, and usefulness aspect 93.75%. Overall, the average score for the LKPD practicality test based on student responses was 88.8%, placing it in the "practical" category.

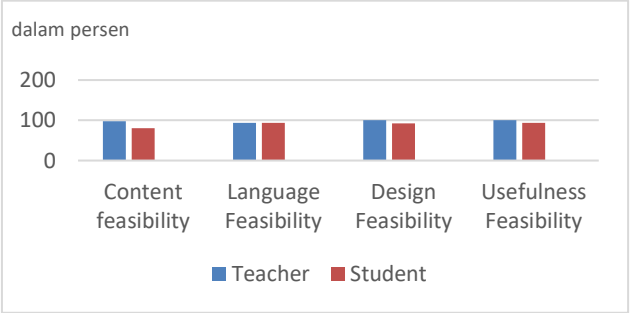

Fig. 10. Results of the teacher and student response questionnaire percentages

Effectiveness Test Result: The average N-Gain score falls within the high category. A total of 79.16% of students achieved scores in the high category, while 20.83% of students were in the medium category.

Table 7. Effectiveness Test Results for LKPD

No.	Criterion	Percentage
1.	High	79,16 %
2.	Medium	20,83 %

3.4 Dissemination

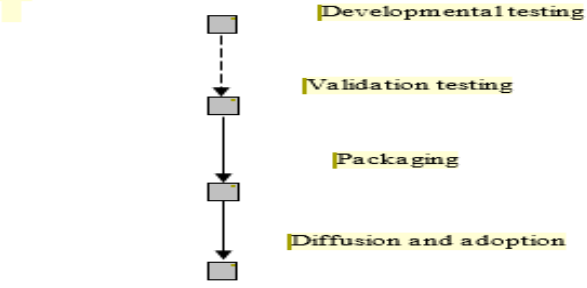

Fig. 11. Dissemination Stage

Finalize the LKPD, package it, and distribute it to teachers and students for implementation in the classroom. Focus on usability and accessibility. This process is divided into three phases:

Final Testing: In this research, no limited trials were conducted.

Packaging: The LKPD products are finalized and packaged into their final format, which, in this case, is a printed product.

Dissemination: The LKPD is distributed and its use is limited to 8th-grade students at SMP Negeri 17 Bulukumba.

4 Conclusion

The results demonstrate that the developed LKPD is valid, practical, and effective in improving student engagement and learning outcomes. The analysis of the validator's results showed an average validity score of 4.5 out of 5, placing it in the "very valid" category. The practicality of the LKPD, based on the ESD principle in the grade VIII statistics material, was assessed using teacher and student questionnaires. The teacher responses indicated that the LKPD had a practicality score of 96.76%, which falls under the "very practical" criteria. Similarly, the student responses showed a practicality score of 88.8%, also classified as "very practical." The effectiveness of the LKPD was evaluated through pre-test and post-test results, followed by an N-Gain test to measure its impact. The analysis revealed that 79.16% (19 students) achieved high scores, while 20.83% (5 students) were in the medium range. The average N-Gain score was 0.76032, which falls into the "high" category.

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