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Development of Student Worksheets for Matrix Topic in Senior High School Mathematics

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ABSTRACT

Despite the growing body of student worksheet development research in mathematics, few studies have integrated real-life economic contexts, particularly the Sustainable Development Goals (SDGs), into matrix learning materials. This study aims to develop and validate an SDG 8-integrated Student Worksheet for matrix learning in grade XI at SMAN 2 Ponorogo and MA Darul Huda Mayak. The method employed is a modified version of Thiagarajan's 4D development model, limited to three stages: define, design, and develop. Two mathematics teachers served as validators, assessing the student worksheet using a content validity questionnaire analyzed with the Gregory formula. The validation results yielded a content validity coefficient of Vc = 1.00, indicating very high validity based on Gregory's criteria (0.80–1.00). The student worksheet is designed to help students understand matrix operations and apply them in real economic contexts relevant to SDG 8 (decent work and economic growth), making it potentially suitable for supporting contextual matrix learning in senior high school.

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1. INTRODUCTION

Effective mathematics learning requires not only the mastery of abstract concepts but also the ability to apply them in meaningful, real-world contexts. In senior high school mathematics, matrix material represents a foundational topic that connects algebraic reasoning with practical applications across science, economics, and technology. However, teaching this material remains challenging: students frequently struggle with matrix operations not due to a lack of prior numerical knowledge, but due to insufficient conceptual scaffolding (Hermanto & Susilawati, 2023). Addressing this gap calls for innovative learning materials that actively engage students and situate mathematical learning within relevant real-life problems. One such approach is the use of inquiry- and discovery-based learning models, in which students are invited to formulate problems, construct hypotheses, collect data, and draw conclusions conclusions (Salmariayah & Wahyuni, 2022). This learning method has proven to be engaging and has increased students' motivation to learn (Ginanjar, 2015). This shows that a learning model applied in an interesting way can increase students' interest in learning. Several studies have confirmed that inquiry- and discovery-based learning effectively develops students' conceptual understanding and problem-solving skills in mathematics (Muhali et al., 2021; Maarif & Soebagyo, 2024).

Learning media can support learning models, making them easier to implement. One of the media that supports this learning model is LKPD (student worksheets). LKPD sheets contain clear materials and instructions for student learning activities, oriented towards the basic competencies to be achieved (Nurdiyanto et al., 2020). Learning activities that use LKPD can help teachers build students' conceptual understanding. The results of research conducted by (Satiti et al., 2023)support this, showing that LKPD has been proven valid and effective in improving students' understanding of concepts. Similarly, Ramadhani & Rahayu (2024) found that well-designed LKPD not only facilitates conceptual understanding but also supports higher-order thinking skills when integrated with active learning strategies.

Mathematics is one of the subjects that prioritizes understanding basic concepts. Based on observations at SMAN 2 Ponorogo, some students still have difficulty with matrix material, especially in matrix operations. Hermanto & Susilawati (2023) found that students' difficulties with matrix material stem from their lack of understanding of matrix concepts. This is in line with what Khairani & Gustianingrum (2021), found: student errors in matrix materials are mostly conceptual and operational. In fact, mathematics is a subject often applied in life, especially in mathematical methods used to analyze inputs and outputs in the economic sector (Disha et al., 2022). Therefore, it is important to develop learning media that support students in better understanding mathematical concepts. This is consistent with findings by Erita et al. (2022), who demonstrated that contextually designed student worksheets significantly improve mathematical reasoning among senior high school students.

Previously, several experts conducted research on the development of LKPD on matrix materials. Imran (2018), have developed a problem-solving-based LKPD for matrix materials. Putri et al. (2022), developed an LKPD based on a scientific approach to matrix material. Then, Sari & Ramury (2023), developed a Student Worksheet (LKPD) using the 5E learning cycle model on matrix topics. Research on the development of LKPD using applications such as GeoGebra, aimed at improving students' understanding of the concept of matrices, has also been carried out (Hanafiah et al., 2024). Beyond these approaches, research using digital and interactive LKPD has also grown, with studies showing high validity and positive student responses (Ramadhani & Rahayu, 2024; Tumangger et al., 2024).

Some of the development research that has been carried out is still rare, focusing on the implementation of matrix materials in real life. Previous research has focused more on learning models integrated with LKPD, such as problem-solving, scientific approaches, and 5E learning cycle models. In fact, the content of the material used is also important, so that students not only understand the formula for solving problems but also know how to use matrices in daily life. An example is the application of the matrix to the Sustainable Development Goals (SDGs) formulated by the United Nations (UN) as a guide to realizing a better future. The matrix itself can be used in SDG 8, which focuses on decent work and economic growth. SDG 8 specifically targets sustainable economic growth, full employment, and decent work for all, making it a highly relevant real-world context for teaching quantitative tools such as matrix operations (Chigbu & Nekhwevha, 2023). Aligning mathematics education with SDG 8 has been shown to increase students' awareness of real economic challenges and strengthen the relevance of abstract mathematical concepts (Younis et al., 2023).

Therefore, this study aims to develop and validate an SDG 8-integrated Student Worksheet (LKPD) for matrix operations learning in grade XI, using a modified 4D development model. The LKPD is designed to support students in understanding matrix concepts both theoretically and contextually, through tasks that connect matrix operations to real-world economic problems aligned with SDG 8 (decent work and economic growth).

2. METHODS

This research employs Thiagarajan's 4D development model (Thiagarajan, Semmel & Semmel, 1974), which originally consists of four stages: define, design, develop, and disseminate. In this study, the researchers implemented only the first three stages — define, design, and develop — due to time constraints and the scope of the research, which focused on producing and validating the LKPD. The dissemination stage is planned for future research. The research was conducted at SMAN 2 Ponorogo and MA Darul Huda Mayak, involving two mathematics teachers who served as expert validators.

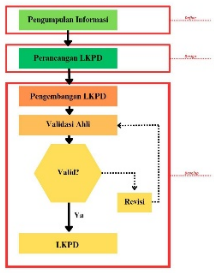

Figure 1. Research Flow for 4D Model Development

Based on **Figure 1**, this study began with an initial analysis that found grade XI students had difficulty understanding the concept of matrix operations. Even though students already have basic knowledge of number operations, they still have difficulty understanding the concepts in the matrix without the teacher's guidance. Conceptual analysis shows that students need to understand matrix definitions, types, sizes, and matrix addition, subtraction, and multiplication operations both theoretically and contextually. To support this, the researcher designed learning activities to help students master the concepts and use the matrix to solve real-world problems related to SDG 8, which focuses on decent work and economic growth. Once the LKPD is developed, it is expected to support students in understanding matrix material in depth and applying it to solve contextual problems.

The purpose of this research is to develop a student worksheet (LKPD) to be carried out at SMAN 2 Ponorogo and MA Darul Huda Mayak, with the research subjects being grade 11 students. The instrument used in this study is a validated questionnaire. Validation by experts is carried out by providing an assessment in the criteria column using numbers 4, 3, 2, or 1 for each question or indicator, according to each aspect of LKPD eligibility. The assessment criteria used were: 4 = very good, 3 = good, 2 = less, and 1 = very little.

The data analysis method in this development research uses expert validation. The validation was carried out to assess the validity of the worksheets developed by the researcher for students. In the expert validation analysis technique, the researcher conducts content validation. Content validation is conducted to assess the suitability of students' worksheets against the developed grid. The formula used to assess content validity holistically is the Gregory formula (Hendryadi, 2000). In this formula, 2 validator experts are needed to assess the suitability of indicators and instrument items, evaluating whether the instrument that has been formed is valid. Gregory's analysis consists of two categories. The first category includes irrelevant (score 1) and less relevant (score 2), which combine into a weak-relevance category. Meanwhile, the second category includes relatively relevant (score 3) and highly relevant (score 4), which are grouped as categories with strong relevance**.** Furthermore, after determining the relevance of each point, a contingency table is used to recategorize 2 people and assign each aspect to an alphabet to calculate the Gregory index, as shown below (Salmariayah and Fina Tri Wahyuni 2022).

The formula for determining Gregory's analysis is as follows:

$$V_c = \frac{D}{A+B+C+D}$$

Description:
V_c= Construct Validity
A = Both examiners disagree
B = Tester 1 agrees, Tester 2 disagrees
C = Examiner 1 disagrees, Examiner 2 agrees
D = Both Examiners agree

The results of the construct validity calculation are then converted into cumulative values in accordance with the following assessment criteria:

Table 1. Gregory's Validity Criteria

Value Range	**Criteria**
0,80 – 1,00	Very High Validity
0,60 – 0,79	High Validity
0,40 – 0,59	Medium Validity
0,20 – 0,39	Low Validity
0,00 – 0,19	Very Low Validity

After the validity calculation using Gregory is changed to cumulative values. The next step is to convert the results and value ranges in the form of numbers into qualitative data (Handoko et al., 2025) in **Table 2**.

Table 2. Benchmark Scale Transforms Results from Numerical Value Range to Qualitative Data

Value Range	Category
3, 26 – 4,00	Excellent
2,51 – 3,25	Good
1,76 – 2,50	Not Good
1,00 – 1,75	Very Bad

3. RESULTS AND DISCUSSION

This section presents the findings of the development process following the three implemented stages of the 4D model: define, design, and develop. The development process resulted in an LKPD for matrix operations integrated with SDG 8 (decent work and economic growth), designed for grade XI students. The product was then subjected to expert validation to assess its content validity.

This study produced an LKPD on matrix operations integrated with SDG 8 for grade XI students. The validation was conducted by two mathematics teachers: Nurul Widayati, S.Pd. (SMAN 2 Ponorogo) and Okta Tri Riyan F (MA Darul Huda Mayak Ponorogo). Both validators assessed the LKPD using a content validity questionnaire covering material feasibility and media aspects. Using Gregory's formula, the content validity coefficient was calculated as $Vc = 4/(0+0+0+4) = 1.00$, which falls within the very high validity range (0.80–1.00). The average validator score also fell in the Excellent category (3.26–4.00) based on the benchmark scale. The development process followed the three stages below.

3.1 Define Stage

The first stage, namely the *definition* stage, is carried out through initial and final analysis, student analysis, tasks, concepts, and the formulation of learning objectives. At this stage, several problems were identified during class XI mathematics learning at SMA Negeri 2 Ponorogo and MA Darul Huda Mayak Ponorogo, including the use of LKS (Student Worksheets) as the sole teaching material in teaching and learning activities. Not only that, the learning method still tends to be teacher-centered, meaning teachers are only explaining the material and asking questions. There have been no media or teaching materials that have motivated and enthused students to learn mathematics. Furthermore, the assignments and concept maps prepared in the module are detailed and structured around the existing problems.

3.2 Design Stage

Next, the *design* stage involves the preparation of the product framework. At this stage, the LKPD format was designed by gathering relevant references on matrix material, selecting appropriate images and fonts, and arranging the layout to be visually appealing and student-friendly. This stage also includes linking the matrix material to SDG 8 (decent work and economic growth) in line with the contextual focus of the LKPD.

3.3 Development Stage

The third stage is developing. At this stage, the researcher converts the design, which is still in the form of a design, into an actual mathematics module. In addition, at this stage, the validation process is carried out by several experts, namely competent mathematicians in their respective fields. The following are the results of the module development.

Figure 2. *Cover* LKPD

Figure 3. Student Identity

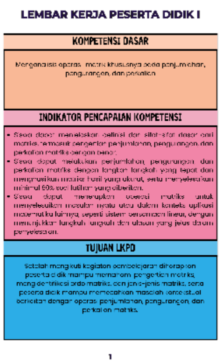

Figure 4. KD and Objectives of LKPD

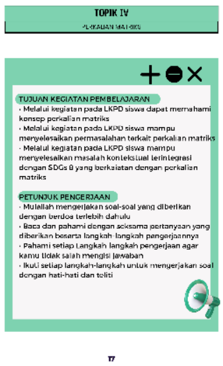

Figure 5. *Cover* each Sub Chapter

The next stage is validation. The validation stage was carried out by Nurul Widayati, S.Pd., a mathematics teacher at SMAN 2 Ponorogo, and Okta Tri Riyan F, a mathematics teacher at MA Darul Huda Mayak Ponorogo. Material-related validation aims to confirm the feasibility and evaluate the content of the developed module material. Meanwhile, the purpose of media-related validation is to assess the correctness of the module's layout and appearance, the content of the material, and the media suitability and students' skills.

The stage after the validation process is carried out is a validation test using the Gregory test, with the following results.

Table 3. Gregory's Validation Test

		Rater 2	
		Less Relevant (score 1-2)	**Highly Relevant (score 3-4)**
Rater 1	Less Relevant (score 1-2)	(A) 0	(C) 0
	Highly Relevant (score 3-4)	(B) 0	(D) 4

Based on the Table 3, the validity coefficient of the instrument's content will be calculated using the following Gregory formula:

$$\text{Contents Validity} = \frac{D}{A + B + C + D} = \frac{4}{4} = 1$$

Based on the above results, when evaluated against the validity criteria for the expert instrument's content in the table above, the material expert validation instrument shows very high validity.

Based on the validation process described above, the LKPD developed through the 4D model (define, design, develop) for matrix material in grade XI has been assessed as having very high content validity (Vc = 1.00). Both validators, who are practicing mathematics teachers at the research sites, rated all four assessed items as highly relevant. This result indicates that the LKPD is valid in terms of content and is ready to be used in further research, including practicality and effectiveness testing in future studies.

4. CONCLUSION

This research produced a Student Worksheet (LKPD) for matrix operations, integrated with SDG 8 (decent work and economic growth), for grade XI students at SMAN 2 Ponorogo and MA Darul Huda Mayak. The LKPD was developed using a modified 4D model limited to the define, design, and develop stages. Expert validation by two mathematics teachers yielded a Gregory content validity coefficient of Vc = 1.00, indicating very high validity. These results show that the developed LKPD is content-valid and suitable as a foundation for further research. Practically, this LKPD offers educators a structured, contextual learning resource that connects matrix operations with real-world economic contexts, potentially making mathematics learning more meaningful for students. However, this study has several limitations: only two validators were involved, no student response or practicality data were collected, and the dissemination stage was not implemented. Future research should test the practicality and effectiveness of this LKPD with actual students, involve independent academic experts as validators, and extend the development to the full 4D model including dissemination.

Specifically, it is recommended that future studies: (1) conduct practicality testing by collecting student and teacher response data; (2) conduct an effectiveness study using pre-post designs to measure learning outcomes; (3) include university lecturers or subject matter experts as validators to ensure objectivity; (4) explore the integration of digital tools (e.g., GeoGebra, interactive worksheets) to enhance engagement; and (5) expand the SDG-integrated LKPD approach to other mathematics topics.

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DECLARATIONS

Author Contributions: AKF: Conceptualisation, Writing-Review & Editing, Visualisation, Data Curation, Methodology, and Investigation; FPO: Conceptualisation, Investigation, Methodology, and Supervision; HM: Conceptualisation, Writing-Original Draft, Data Curation, Formal Analysis, and Methodology; ADK: Conceptualisation, Writing-Original Draft, Investigation, Visualisation, Resources, and Validation.

Conflict of Interest: The authors declare that they have no competing interests.

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