Development of a CTL-Based E-Worksheet to Strengthen Junior High School Students' Problem-Solving Skills on Systems of Linear Equations in Two Variables

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Abstract

The lack of mathematical problem-solving ability of junior high school students causes difficulties in learning the System of Linear Equations in Two Variables and in solving problems according to the stages of mathematical problem solving. This indicates that students' mathematical problem-solving skills, including in the topic of the System of Linear Equations in Two Variables, are still relatively weak. This study aims to develop a valid and practical E-LKPD to strengthen students' problem-solving abilities related to the System of Linear Equations in Two Variables at the junior high school level. The development of the E-LKPD employed a design research methodology of the development study type, focusing on the process of developing and refining the learning product through formative evaluation. The formative evaluation phase resulted in a score of 88% for validity—covering content, construct, and language aspects—during the expert review stage, and a score of 81.6% for practicality during the small-group stage. The developed E-LKPD was proven to be feasible and practical for use as instructional material in the learning process of the System of Linear Equations in Two Variables. Furthermore, this E-LKPD was also able to strengthen junior high school students' problem-solving abilities related to the System of Linear Equations in Two Variables.

Keywords

E-LKPD, SPLDV, Problem Solving Skills

Introduction

Technology serves as an essential tool that supports humans in carrying out various daily activities, including in the field of education (Maritsa et al., 2021). The integration of technology in learning is no longer optional but has become a necessity to ensure that the teaching and learning process is more engaging, interactive, and relevant to the demands of the 21st century (Banarsari et al., 2023). In the context of 21st-century education, particularly within the independent curriculum, students are expected to acquire knowledge through applications, real-world experiences, and examples from both inside and outside the school environment (Humayra et al., 2025). In this regard, students are required to master four essential skills known as the 4Cs (Critical Thinking, Communication,

Collaboration, and Creativity) as foundational competencies to face global challenges (Partono et al., 2021). To achieve this, teachers play a crucial role in creating active, enjoyable, and meaningful learning experiences through the effective use of digital technology.

Mathematics is a tool that helps students confront problems and challenges in personal, social, and professional aspects of life (Hayati & Jannah, 2024). This subject is taught at every level of education to equip students with the ability to solve problems rationally and creatively (Siahaan & Surya, 2020). However, many students perceive mathematics as a difficult, confusing, and irrelevant subject (Dwiguningtyas et al., 2025). One of the topics introduced at the junior high school level is the system of linear equations in two variables. Since this topic is new for most junior high school students, they must recall prior knowledge and understand the underlying concepts (Indah & Hidayati, 2021). Consequently, students often encounter difficulties in learning the system of linear equations in two variables.

Students' difficulties in learning the system of linear equations in two variables can lead to low problem-solving abilities. Anggraeni & Haerudin, (2022) highlight that students' mathematical problem-solving skills remain very limited, as they struggle to complete tasks aligned with the stages of mathematical problem solving. This indicates that students' mathematical problem-solving abilities, particularly in the system of linear equations in two variables, are still weak. One contributing factor is the continued use of conventional, teacher-centered approaches and the limited integration of technology in the learning process. During lessons, students only listen to the teacher's explanations and take notes from the board (Susanti et al., 2024).

To improve students' problem-solving abilities, teachers need to adopt learning strategies that enable students to develop logical, creative, and analytical thinking skills in solving mathematical problems (Sari, 2023). One such strategy is the use of technology-based instructional materials such as E-LKPD. LKPD refers to a collection of worksheets containing student activities that allow them to engage directly with objects and problems being studied (Hairani & Setiawan, 2022). E-LKPD, on the other hand, is defined as an electronic learning medium consisting of tasks that students must complete (Sari et al., 2022). Research by (Panjaitan et al., 2023) indicates that E-LKPD is effective in enhancing mathematical problem-solving abilities and fostering students' learning independence. Furthermore, the study by Prasanti et al. (2025) concludes that the use of E-LKPD

contributes to a more relevant, engaging, and comprehensible mathematics learning experience.

Based on these issues, it is necessary to develop technology-based instructional materials in the form of E-LKPD to strengthen junior high school students' mathematical problem-solving abilities, particularly in the topic of systems of linear equations in two variables. Therefore, this study aims to develop a valid and practical E-LKPD to strengthen problem-solving skills related to systems of linear equations in two variables among junior high school students.

Methods

The method used in this study is Design Research of the Development Study type, which focuses on the process of developing and refining learning products through formative evaluation. The foundation for using this method refers to the formative evaluation framework (Tessmer, 2013; Zulkardi, 2002). The sequence of the formative evaluation stages is presented in Figure 1.

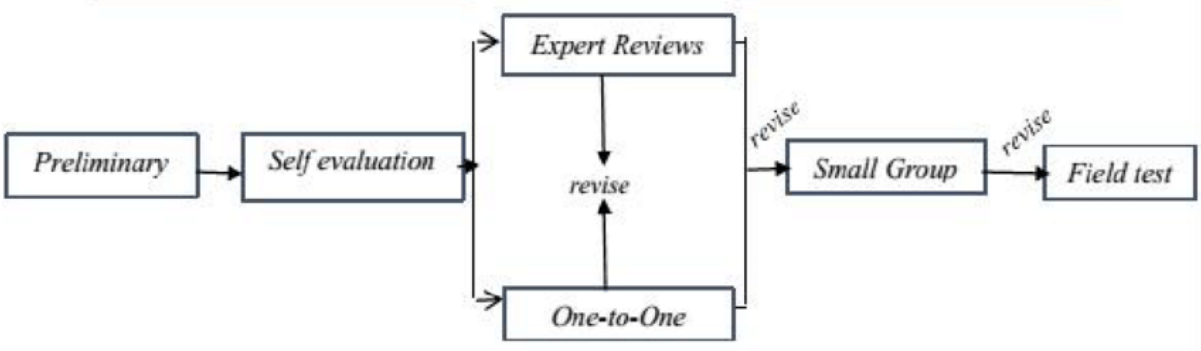

Figure 1. Flow of the Formative Evaluation Stages

The development stages begin with a self-evaluation, which aims to identify potential shortcomings in the product being developed. In this stage, the researchers carry out two activities: preparation and design. The preparation activities include curriculum analysis, material analysis, and analysis of student characteristics, followed by the design stage to produce Prototype I. Prototype I then undergoes both expert review and one-to-one evaluation. In the expert review stage, Prototype I is validated by experts to assess the media aspects, which include content, construct, and language. Subsequently, the one-to-one stage is conducted by testing Prototype I on three students with high, medium, and

low abilities to obtain feedback related to clarity, readability, and practicality of the product. The comments and suggestions obtained from these two stages are used to revise and improve the product, resulting in Prototype II.

The next stage is the small group evaluation, in which Prototype II is tested on a small group of five students with varying ability levels to examine the practicality of the developed product. Suggestions and comments obtained at each stage are analyzed quantitatively to obtain scores using a 5-point Likert scale, with the Likert scale categories presented in Table 1.

Table 1. Likert Scale

Score	Description
1	Strongly Disagree
2	Disagree
3	Neutral
4	Agree
5	Strongly Agree

Source : (Sugiyono, 2018)

The researcher then conducted a qualitative analysis to describe the suggestions and comments provided, as well as to explain the categories of validity and practicality scores. The categories of validity and practicality scores are presented in Table 2.

Table 2. Validity and Practicality Score Categories

Score Interval	Category of Validity	Category of Practicality
80% ≤ Skor ≤ 100%	Highly Valid	Highly Practical
60% ≤ Skor < 80%	Valid	Practical
40% ≤ Skor < 60%	Moderately Valid	Moderately Practical
20% ≤ Skor < 40%	Less Valid	Less Practical
0% ≤ Skor < 20%	Invalid	Impractical

The calculation formula used to determine the score is as follows:

$$Score = \frac{The\ total\ score\ obtained}{Maximum\ score} \times 100\%$$

Result and Discussion

Analysis Stage

In the initial development stage, the researcher conducted a comprehensive analysis and evaluation of the system of linear equations in two variables material to ensure its alignment with the characteristics of the E-LKPD based on TopWorksheet and the

contextual problem-solving approach to be implemented. The analysis was carried out by reviewing the alignment between learning outcomes and objectives, the conceptual structure, and potential student misconceptions related to learning system of linear equations in two variables.

Recent studies indicate that junior high school students still encounter various difficulties in understanding system of linear equations in two variables, particularly in converting contextual problems into mathematical models and performing algebraic procedures systematically (Nofiansyah et al., 2023). Similar findings were reported by Lestari & Afrilianto, (2021), who emphasized that limited understanding of problem narratives leads students to struggle in constructing equations that represent the problem situation.

Moreover, students' conceptual understanding of system of linear equations in two variables has been shown to be closely related to learning motivation, as demonstrated in the study by Arifudin et al., (2025), which found that strong motivation contributes to students' ability to model and solve system of linear equations in two variables. In addition, students' mathematical reasoning regarding system of linear equations in two variables has been found to remain at a moderate level, indicating the need for an instructional design that stimulates higher-order thinking processes (Nurhalin & Effendi, 2022). Similar tendencies were reported by (Midawati, 2022), stating that some students were still unable to construct systematic and logical solution steps for system of linear equations in two variables problems.

Based on these findings, the researcher conducted an evaluation of the content and activity flow within the E-LKPD to ensure its ability to integrate authentic contexts relevant to students' daily lives while supporting mathematical thinking processes. The results of this analysis and evaluation served as the foundation for the initial design process before entering the formative evaluation phase of this study.

Formative Evaluation Stage

Self-Evalution

In the self-evaluation phase, the researcher conducted an initial review of the TopWorksheet-based E-LKPD design that had been developed. This evaluation included examining the alignment of the activity flow with the learning objectives of the system of linear equations in two variables, the appropriateness of authentic context integration, and

the coherence of the user-interface layout. The researcher ensured that each component of the E-LKPD facilitated conceptual scaffolding, beginning from the introduction of the context, to problem modeling, and finally to solving the system of equations.

The review also focused on the clarity of instructions, accuracy of content, interactivity of the worksheets, and the suitability of the design with principles for developing digital worksheets, such as readability, navigation, and responsiveness. This internal review was grounded in the principle that educational products must undergo self-evaluation as an initial step before expert validation or user testing, as recommended in development research frameworks (Gravemeijer & Cobb, 2006)(McKenney & Reeves, 2018).

The results of the self-evaluation indicated that the E-LKPD had met the necessary basic structure and pedagogical functions, and was therefore appropriate to proceed to the expert validation stage.

Expert Review

In this stage, the researcher conducted the validation of the E-LKPD by involving one expert, a lecturer from the Mathematics Education Study Program at Universitas Sriwijaya who specializes in the development of instructional media. This phase was carried out to validate the quality of the E-LKPD in terms of content, construct, and language. The reviewer assessed that the E-LKPD on the system of linear equations in two variables was in the "good" category and suitable for use, noting that the contextual problems were realistic, the reasoning flow was systematically arranged, and the activities supported students' modeling and problem-solving competencies.

However, the expert provided several suggestions for improvement, including adjusting the color scheme to be more user-friendly, revising the wording of instructions in the SLETV modeling section, refining typography, and reducing excessive decorative elements. All of these inputs were then used as the basis for revising the E-LKPD into Prototype II, which would subsequently be tested in the small group stage. Table 3 presents the expert's validation results.

Table 3. Expert Review Validation Results

Validity Assessment	Validity Score	Category
Content Validation	88%	Highly Practical
Construct Validation	92%	Highly Practical
Language Validation	84%	Highly Practical
Average Total Score	**88%**	**validasi**

Based on the assessment provided by the validator above, it can be concluded that this E-LKPD is valid and can be used for the next stage, namely the small group phase. However, the researcher still made revisions to Prototype I based on the comments and suggestions given by the validator in order to improve the quality of the product.

One To One

In the one-to-one phase, the researcher tested Prototype I on three students with high, medium, and low abilities to obtain feedback regarding the clarity, readability, and practicality of the product. The one-to-one phase was conducted concurrently with the expert review stage. The researcher provided the TopWorksheet-based E-LKPD link to the three junior high school students and asked them to complete the tasks. In this phase, the researcher acted as a facilitator, assisting the students and guiding them throughout the completion process.

After the students completed the tasks, the researcher asked for their opinions regarding the E-LKPD they had used. They provided comments and suggestions, which served as the basis for revising the product and developing Prototype II. Table 4 presents the comments and suggestions obtained from the one-to-one phase.

Table 4. Feedback from the One-to-One Phase

Initials of Students	Feedback
GPS	For question number 4, it seemed a bit unusual to me because the steps for solving it were different from what I have learned.
PA	The questions were a mix of difficult and easy, and it was confusing to solve them without guidance.
ALA	The boxes in the E-LKPD were too small, causing the text inside them to be cut off when filled in.

After the one-to-one phase was completed, the researcher revised Prototype I into Prototype II based on the comments and suggestions obtained from the expert review and one-to-one phases, which would subsequently be tested in the small group stage.

Small Group

In the Small Group phase, the researcher tested the revised E-LKPD Prototype II, which had been updated based on the comments and suggestions provided during the expert review and one-to-one phases. Prototype II was tested on a small group consisting of five junior

high school students. This phase aimed to determine the practicality of the developed E-LKPD.

In this phase, students completed the TopWorksheet-based E-LKPD displayed on a single device provided by the research team, specifically a laptop used to access the E-LKPD. Before starting, the researcher instructed the students to read the task instructions and explained how to complete the TopWorksheet-based E-LKPD. Afterwards, the students were given time to complete the activities in the E-LKPD while discussing within their group, and were allowed to ask the research team directly for guidance if they encountered any difficulties.

After completing the E-LKPD, the researcher provided each student with a practicality assessment sheet containing ten statements to evaluate the practicality of the E-LKPD. The results of the students' practicality assessments using a Likert scale are presented in Table 5.

Table 5. Small Group Practicality Assessment Results

Practicality Assessment	**Total Score**
Student 1	32
Student 2	40
Student 3	44
Student 4	40
Student 5	48
Average Score	40.8
Average Score Percentage	81.6%
Practicality Category	**Highly Practical**

Based on the results presented in the practicality assessment table given to each student, the E-LKPD obtained a practicality score of 81.6%, which falls into the "highly practical" category. Therefore, it can be concluded that, through the small group phase, the E-LKPD developed by the researcher is considered highly practical for use.

Coclusion

The final result of developing the E-LKPD based on the contextual teaching and learning approach was categorized as highly practical, as demonstrated through the small group test involving five junior high school students, which produced an average practicality score of 81.6%, classified as very practical. Thus, the developed E-LKPD is proven to be feasible and practical for use as instructional material in the teaching and learning process of the system of linear equations in two variables. Furthermore, this E-LKPD is also capable of

strengthening students' problem-solving abilities related to systems of linear equations in two variables, as it includes step-by-step guidance for solving problems within this topic. The testing in this study was still limited to a small scale, reaching only the small group stage. Therefore, future research is expected to assess the E-LKPD in a broader setting, particularly at the field test stage, in order to obtain quantitative data regarding its effectiveness in improving students' problem-solving abilities.

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