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THE DEVELOPMENT OF MATHEMATICS ELKPD ASSISTED BY FLIPBOOK BASED ON DISCOVERY LEARNING TO IMPROVE STUDENTS' LEARNING OUTCOMES

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Abstract
This study aims to develop an educational resource in the form of an electronic student worksheet (ELKPD) supported by a flipbook and based on the Discovery Learning model, to improve students' learning outcomes on the topic of plane figures at SMP Negeri 1 Rengel. The background to this research stems from the low mathematics achievement among students, attributed to limited interest in learning and the lack of interactive teaching media suited to students' needs. The study adopts a Research and Development (R&D) approach, utilizing the 4D development model (Define, Design, Develop, Disseminate), although it is implemented only up to the development stage. The instruments employed include expert validation sheets, practicality questionnaires, and learning outcome tests. The findings reveal that the developed ELKPD falls into the categories of valid, practical, and effective for classroom use. The Flipbook-assisted ELKPD based on Discovery Learning significantly enhanced students' engagement, learning independence, and learning outcomes. Therefore, this teaching

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medium is considered suitable to be used as an alternative instructional resource in mathematics learning, contributing to the improvement of educational quality.

INTRODUCTION

Education plays a vital role in preparing young generations to face the challenges of an everchanging world, particularly in the current era of globalisation (Nurrita, 2018). The rapid development of information and communication technology has transformed the way people interact and share information swiftly and effectively (Amin & Mayasari, 2015). This situation compels the education sector to evolve continuously in order to produce high quality graduates who are competitive on a global scale. According to (Nurrita, 2018), technological advancements have had a significant impact on educational systems, as reflected in the shift from traditional learning methods towards digital learning (Ribca Rahel Br. Purba, 2023).

The learning process is inseparable from the use of instructional media, teaching methods, and the learning outcomes achieved by students. In this context, mathematics stands out as a subject that particularly requires innovative teaching approaches. Beyond being a fundamental science, mathematics plays a crucial role in the advancement of science and technology (Indriani, 2016). However, in practice, many students perceive mathematics as a difficult and confusing subject, which in turn has a negative impact on their academic performance.

According to (Handayani, 2019), learning outcomes reflect changes in students' behaviour resulting from the learning process, which can be measured across three main domains: cognitive, affective, and psychomotor. Meanwhile, (Firmansyah, 2015) notes that academic achievement can also be identified through scores represented by letters, symbols, or numbers. Thus, mathematics learning outcomes encompass a range of assessment aspects that indicate the extent to which students understand and master the subject matter. However, the latest report from the Programme for International Student Assessment (PISA) in 2022, published by the OECD, shows that Indonesian students' mathematical proficiency remains relatively low, with an average score of 366, placing Indonesia 70th out of 81 participating countries. This reality highlights the urgent need to improve teaching strategies, particularly regarding the methods and instructional media employed in mathematics education.

(Sugiarto, 2020) explains that students' learning outcomes are influenced by two main factors: internal factors (such as students' psychological and physiological conditions) and external factors (including environment, family, school, and teaching methods). Since teaching methods fall within the scope of external factors, teachers are therefore required to adopt methods that are relevant and aligned with the characteristics of the subject being taught.

Based on observations and interviews conducted at SMP Negeri 1 Rengel, students' mathematics achievement can be categorized as low when examined quantitatively. The results of the end of semester assessment showed that only 63 out of 256 seventh grade students (24.6%) achieved the Minimum Mastery Criterion (KKM), while the remaining 75.4% scored below the required standard. Furthermore, the average score obtained by students prior to the implementation of the learning intervention was 46, which is considerably lower than the expected competency level. These data indicate that the majority of students experience significant difficulties in understanding basic mathematical concepts, particularly in plane figures. This condition is

consistent with national and international assessments. According to the Programme for International Student Assessment (PISA) 2022 report, Indonesian students obtained an average mathematics score of 366, placing Indonesia among the lower performing countries. This finding suggests that the problem of low mathematics achievement is not only local but also reflects broader challenges in mathematics education, thereby strengthening the need for effective instructional innovations.

In addition to the limited availability of interactive learning media, students' low interest and engagement in mathematics learning are closely related to the instructional approach employed in the classroom. Conventional teacher centered methods tend to position students as passive recipients of information, which may reduce their curiosity and motivation to learn. Discovery Learning, as proposed by Bruner, emphasizes active student involvement in exploring, investigating, and constructing mathematical concepts independently. Through guided discovery, students are encouraged to ask questions, test ideas, and draw conclusions, thereby fostering intrinsic motivation and learning engagement (Said et al., 2019).

The Discovery Learning model is particularly relevant to the topic of plane figures, as this material involves visual and conceptual relationships that can be explored through observation and manipulation. By discovering properties such as area, perimeter, and geometric relationships through structured activities, students are more likely to develop a deeper conceptual understanding and sustained interest in learning mathematics. This pedagogical approach allows abstract concepts to become more concrete and meaningful, which is essential for improving students' engagement and learning outcomes (Salsabila et al., 2023).

This issue has prompted the researcher to examine the underlying factors contributing to students' low learning outcomes. One of the main factors identified is the use of teaching materials that fail to capture students' interest and do not actively engage them in the learning process. In addition, limited instructional time and an overreliance on lecture-based methods have made it difficult for students to fully grasp the material, particularly in the topic of plane figures. The teaching process, which primarily depends on printed materials and the blackboard, has also yet to make optimal use of the technology available in today's digital era.

As a potential solution, teachers need to innovate by selecting instructional media that can spark students' interest and encourage active participation during lessons. One promising alternative is the development of electronic student worksheets (ELKPD) supported by Flipbook technology and combined with the Discovery Learning model. This approach allows students to learn independently, actively, and creatively through a guided discovery process led by the teacher. When integrated with a Flipbook assisted ELKPD, Discovery Learning can be implemented more effectively through interactive visuals, guided tasks, and sequential learning activities. The ELKPD functions as a digital scaffold that supports each stage of the discovery process, enabling students to learn independently while remaining actively engaged throughout the learning experience (Fitni et al., 2023).

The use of ELKPD aligns with the demands of the 21st century, which require the integration of technology into teaching and learning processes (Suryaningsih & Nurlita, 2021). Moreover, Flipbook, as a digital medium, offers visually appealing and interactive features that can enhance students' understanding of the subject matter. Research by (Rahayu et al., 2022) has shown that the digitalisation of learning can simplify the evaluation process and improve the overall effectiveness

of instruction. However, the effectiveness of such media can be maximised when combined with an appropriate instructional model, one of which is Discovery Learning, as proposed by Jerome Bruner. This model emphasises the importance of students' active engagement in constructing and discovering learning concepts themselves.

Through this approach, students are encouraged to construct their own understanding based on their learning experiences. Therefore, the development of Flipbook assisted ELKPD grounded in the Discovery Learning model is considered highly relevant in addressing existing challenges in mathematics education. Previous studies have supported the effectiveness of using Flipbook assisted ELKPD. For example, research conducted by (Haspari, 2023) and (Diamudrika, 2024), found that this medium is valid, engaging, practical, and capable of improving students' learning outcomes. Nevertheless, some studies have also identified certain challenges in its implementation, highlighting the need for further development to optimise its use in classroom practice.

Based on the discussion above, the researcher considers that developing a Flipbook assisted ELKPD based on the Discovery Learning model is highly necessary. This instructional medium not only offers greater flexibility in the learning process but also encourages students to become more active, think critically, and develop a stronger interest in mathematics. In doing so, it is hoped that students' learning outcomes will improve, while also better preparing them to face future educational challenges.

METHODS

This study adopts a Research and Development (R&D) approach with the aim of developing and testing the effectiveness of a Flipbook assisted Mathematics ELKPD based on the Discovery Learning model, designed for teaching plane figures to Year VII students at SMP Negeri 1 Rengel.

This study adopted the 4-D development model consisting of Define, Design, Develop, and Disseminate stages. However, the implementation was intentionally limited to the Develop stage because the primary objective was to examine the feasibility of the developed E-LKPD in terms of validity, practicality, and effectiveness within a specific classroom context. At this stage, the product had undergone expert validation, field testing, and effectiveness evaluation, which were sufficient to determine its instructional quality. Therefore, the Disseminate stage, which focuses on large-scale implementation and broader adoption, was considered beyond the scope of this study and is recommended for future research.

As the development process was limited to the Develop stage, the findings are context-specific and confined to the characteristics of the research participants. The results demonstrate the feasibility and effectiveness of the developed ELKPD within the selected class and school setting; however, they are not intended for broad statistical generalization. Further studies involving wider implementation across different schools and student populations are required to strengthen external validity and generalizability.

The dissemination stage of the 4D model was not conducted in this study because the primary focus was on ensuring the feasibility and instructional quality of the developed ELKPD. The product had been validated by experts and tested in classroom implementation, which was sufficient to determine its validity, practicality, and effectiveness. Largescale dissemination requires broader institutional support and extended implementation time, and thus is suggested for future studies.

The effectiveness of the developed ELKPD was evaluated using a one group pretest–posttest design. Students were given a pretest before the implementation of the Flipbook assisted ELKPD based on Discovery Learning and a posttest after the learning intervention. The test scores were then compared to determine the improvement in students' learning outcomes. The learning outcome test consisted of five essay items designed to measure students' understanding of plane figures. The test was administered both as a pretest and a posttest and had been validated by experts and tested for reliability prior to its use. To measure the effectiveness of the learning media, students' pre-test and post-test scores were analyzed using the normalized gain (N-gain) formula. The N-gain value was interpreted based on established criteria, where values above 0.70 indicate a high level of improvement. In addition, descriptive analysis was conducted by comparing the average pre-test and post-test scores.

In this study, the Flipbook is not merely used as a digital document format but functions as an interactive learning medium that supports the Discovery Learning process. The Flipbook contains dynamic page navigation, visual illustrations, step-by-step guided activities, and embedded prompts that encourage students to explore, observe, and construct mathematical concepts independently. These features enable students to actively engage with the learning material rather than passively read static content.

This study employed both qualitative data (interviews, observations, and documentation) and quantitative data (questionnaires and test results). The data sources comprised primary data (respondents, students, teachers, and validators) and secondary data (school documents and supporting literature). The research subjects consisted of 32 seventh grade students from class VIIE at SMP Negeri 1 Rengel. The class was selected using random sampling from a population of 256 seventh grade students. This sampling technique was applied to provide equal opportunity for each class to be selected and to minimize selection bias. The research instruments included: validation sheets assessed by subject matter and media experts; pretests and posttests; questionnaires to gather responses from teachers and students; as well as observation, interview, and documentation guidelines. For data analysis, the study applied several procedures: instrument testing included validity testing (using Aiken's V index), Practicality testing was carried out using questionnaires measured on a Likert scale, while effectiveness was assessed through an N-Gain test, alongside an analysis of learning outcomes by comparing pretest and posttest scores. For the validation process, two experts were involved: Mr. Drs. Sujiran, M.Pd., a mathematics lecturer, and Mrs. Siti Maftukhah, S.Pd., a mathematics teacher for Year VII.

Additional assessments include testing the validity of the instruments to be employed (using Aiken's V), as well as analysing their reliability (Cronbach's Alpha), the level of item difficulty, and the discriminatory power that distinguishes between high and lowability students. Through this approach, it is anticipated that the ELKPD developed will not only be valid and practical, but also effective in enhancing students' mathematics learning outcomes.

RESULT AND DISCUSSION

This section presents the results of the validity, practicality, and effectiveness testing of the developed ELKPD. The trial of the test instrument was conducted to ensure that the items used in the learning outcome assessment were genuinely valid and appropriate for application within the research class context. The learning outcome instrument was administered during both the pretest

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and posttest stages in the research class. Subsequently, each item was analysed for validity, reliability, difficulty level, and discriminating power to guarantee the quality of the questions.

To empirically support this pedagogical integration, the results of the instrument validity test are presented in Table 1.

Tabel 1. Validity test results

Item	V	Description
Item 116	0.85	Highly Valid

The results of the instrument validity test are presented in Table 1. The validity calculation produced an index value of 0.85. According to the established criteria, an index of 0.85 places the instrument within the highly valid category. The validity analysis showed that the ELKPD achieved high validity, with Aiken's V values of 0.91 from material experts and 0.92 from media experts, both categorized as highly valid (V > 0.80). The subsequent stage was the reliability test, which yielded the following results:

Tabel 2. Reliability test results

Sigma Variance	Total Variance	r_{11}	Category
90.32	346.26	0.92	Very High

The reliability of the learning outcome test was measured using Cronbach's Alpha. The analysis yielded a coefficient of 0.92, indicating very high reliability. This result suggests that the instrument consistently measures students' learning outcomes. In addition, expert validation involved agreement among validators regarding content relevance and media suitability, indicating a high level of consistency in expert judgment. Following this, an analysis of the difficulty level of the five items was conducted, with the results outlined as follows:

Tabel 3. Results of the difficulty level test

Item Number	Difficulty Level	Category
1	0.72	Low difficulty
2	0.45	Medium difficulty
3	0.42	Medium difficulty
4	0.32	Medium difficulty
5	0.28	Difficult

The results of the difficulty level analysis revealed that three items fell into the moderate category, while two items were categorised as easy and difficult, respectively. Overall, the quality of the questions can therefore be considered reasonably balanced in terms of difficulty level. The calculation of the discrimination power test was then carried out as follows:

Tabel 4. Results of the discrimination power test

Item Number	Discrimination power	Criteria
1	0.35	Good
2	0.34	Good

3	0.32	Good
4	0.31	Good
5	0.31	Good

Based on the calculation of the discrimination power for items 1 to 5, the results fall within the good category. This indicates that the items are effective in distinguishing between students of higher and lower ability levels. Taken together with the results of the reliability test, the difficulty level analysis, and the discrimination power evaluation, the five items are considered suitable for use as assessment instruments, meeting the required standards of validity and appropriateness for measuring students' abilities.

After testing the test instruments, a largescale trial was conducted on students in class VIIE at SMP Negeri 1 Rengel. The largescale trial began with administering a pretest to the students. The students' pretest scores averaged 46, which means they still did not meet the minimum competency standard (KKM). Therefore, the next step involved implementing the ELKPD media assisted by a Flipbook based on Discovery Learning for the students of class VIIE. Before the ELKPD was tested on the students, the media was first tested for suitability by media and subject matter experts. The media expert validator was one person, Dr. Ahmad Kholiqul Amin, S.Pd., M.Pd, a mathematics lecturer. The media expert validator's role was to provide suggestions and evaluations regarding the suitability of the media's appearance, content, and integration. The results of the media expert's evaluation are as follows:

Tabel 5. Average results of Material Expert Validation

Item	**V**	**Description**
Item 117	0.92	Highly Valid

Based on the average Vindex score obtained from the media expert validation, the ELKPD achieved a score of 0.92, which falls into the "highly valid" category. Therefore, the ELKPD was deemed suitable and approved for largescale trials.

Subsequently, content validation was conducted by two subject matter experts: Ms. Siti Maftukhah, S. Pd, a mathematics teacher, and Ms. Anis Umi K., S. Pd., M. Pd, a mathematics lecturer. These validators were responsible for evaluating the relevance and accuracy of the content and questions included in the ELKPD. The results of this validation are presented in the following table:

Tabel 6. Average results of Material Expert Validation

Item	**V**	**Description**
Item 117	0.91	Highly Valid

The validity of the developed ELKPD was further evaluated by material and media experts. Based on the content validation results, the average Aiken's V score was 0.91, which falls into the highly valid category. The validity analysis showed that the Flipbook-assisted E-LKPD achieved high validity, with Aiken's V values of 0.91 from material experts and 0.92 from media experts. According to the established criteria (V > 0.80), both results fall into the highly valid category.

These findings indicate that the content accuracy, instructional design, visual appearance, and alignment with the Discovery Learning model meet expert standards for instructional feasibility.

After passing the validation by media and content experts, a largescale trial was conducted by implementing the Flipbookassisted Mathematics ELKPD based on the Discovery Learning model. This largescale trial aimed to further assess the feasibility and practical application of the developed ELKPD in an actual classroom setting. After implementing the media in the classroom, the next stage was administering a posttest. The posttest aimed to measure students' mastery of the material after using the ELKPD. The results showed an average score of 86, which is above the Minimum Mastery Criterion (KKM). This result indicates that the ELKPD effectively improved student's learning outcomes.

Following the posttest, a questionnaire was distributed to both students and the mathematics teacher to evaluate the practicality of the ELKPD. The questionnaire results from the mathematics teacher are as follows:

Tabel 7. Teacher Response Questionnaire Results

Question Item Number	Total (S)	Maximum Score (N)	Average
Item Soal 122	106	110	96.4

Based on the questionnaire results completed by the teacher, a score of 96.4 was obtained, which falls into the "highly practical" category. This score indicates that the teacher's response to the use of the ELKPD was very positive; the ELKPD was considered engaging and easy to use for delivering the material. Therefore, the media was deemed practical for classroom application.

Meanwhile, the student response questionnaire aimed to gather students' perspectives on the use of the Mathematics ELKPD. The results of the student responses are as follows:

Tabel 8. Student Response Survey Results

Responden	Question Item Number	Average
132	124 Item	91.48

The practicality of the developed E-LKPD was assessed through response questionnaires administered to teachers and students after classroom implementation. The teacher response questionnaire resulted in an average score of 96.4%, indicating a highly practical category. Meanwhile, student responses showed an average practicality score of 91.48%, with the majority of students agreeing that the E-LKPD was easy to use, engaging, and helpful in understanding plane figure material. These results demonstrate that the E-LKPD can be effectively implemented in classroom learning with minimal technical difficulty.

Furthermore, to assess the effectiveness of the learning media, an N-Gain test was conducted by comparing students' pretest and posttest scores. The results of the N-Gain analysis are presented below:

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Tabel 9. N-Gain Test Results

Responden	Ideal Score (*pretest*)	*N-Gain Score*
132	54.31	0.75

The effectiveness of the Flipbook-assisted E-LKPD was measured using a one-group pre-test–post-test design. The results showed that the average pre-test score was 46, while the average post-test score increased to 86. To quantify the level of improvement, an N-gain analysis was conducted, resulting in a score of 0.75, which falls into the high category. This indicates a substantial improvement in students' learning outcomes after the implementation of the E-LKPD. Thus, the developed learning media proved effective in supporting students' understanding of mathematical concepts during the learning process. By providing detailed information regarding instrument reliability, expert validation criteria, sample size, and sampling technique, this study ensures methodological transparency, thereby enhancing its replicability and research credibility. The N-gain analysis yielded a value of 0.75, which falls into the high category. This indicates a significant improvement in students' learning outcomes after the implementation of the Flipbook-assisted E-LKPD.

The following discussion elaborates on the findings by explaining their pedagogical implications and relevance to mathematics learning. These findings indicate that the integration of Discovery Learning principles within the Flipbook-assisted ELKPD plays an important role in supporting students' active learning processes. The findings of this study are consistent with previous research that reported positive effects of Flipbook-assisted E-LKPD on students' learning outcomes. Studies by Haspari (2023) and Diamudrika (2024) found that Flipbook-based digital worksheets increased student engagement and learning achievement. However, this study extends previous findings by explicitly embedding Discovery Learning stages into the E-LKPD structure, thereby positioning the media not only as a digital worksheet but also as a pedagogical scaffold that guides students through systematic concept discovery. Compared to conventional digital worksheets or static PDF-based materials, the developed E-LKPD provides a more structured and interactive learning experience. The explicit alignment between Flipbook features and Discovery Learning syntax represents a pedagogical innovation that enhances both student engagement and conceptual understanding, particularly in junior high school mathematics learning.

Several previous studies have reported the effectiveness of Flipbook-assisted ELKPD in improving students' learning outcomes. However, most of these studies focused primarily on media presentation rather than pedagogical integration. The Flipbook assisted ELKPD responds to these trends by providing a visually rich, interactive, and accessible learning medium that encourages active student engagement and independent learning, particularly for junior high school students. This pedagogical integration strengthens the role of ELKPD as an instructional scaffold aligned with student-centered digital mathematics learning.

Although various studies have developed ELKPD and Flipbook based learning media, the uniqueness of this study lies in the systematic integration of Discovery Learning syntax into the structure of the ELKPD. Each learning activity is explicitly designed to guide students through stages of stimulation, problem identification, data exploration, verification, and generalization. As a result, the ELKPD functions not merely as a digital worksheet, but as a pedagogical scaffold that

supports students' conceptual discovery in mathematics learning. This finding is in line with current trends in digital mathematics education, which emphasize student centered learning, interactive digital scaffolding, and the integration of technology to support conceptual understanding. The topic of plane figures is highly visual and relational, making it suitable for discovery-based exploration supported by interactive media. The Flipbook facilitated students' understanding by transforming abstract geometric concepts into concrete visual experiences. As students interacted with illustrations and problem scenarios, they were better able to identify relationships among geometric elements, such as sides, angles, and area, which contributed to deeper conceptual understanding.

The Flipbook-assisted E-LKPD was designed to align explicitly with the stages of the Discovery Learning model. The stimulation stage is facilitated through visual problems and contextual illustrations presented in the Flipbook. During the problem identification and data collection stages, students are guided by interactive questions and tasks embedded within the Flipbook pages. The verification and generalization stages are supported by structured reflection prompts and summary activities that help students formulate and validate their findings. Thus, the Flipbook serves as a digital scaffold that operationalizes the Discovery Learning syntax.

In summary, based on the results of the test instrument trials and feasibility analysis, the developed ELKPD has met the criteria for feasibility namely, it is valid, practical, and effective for use in the learning process and has been shown to improve students' learning outcome.

CONCLUSIONS

This study developed a Flipbook-assisted Mathematics ELKPD based on the Discovery Learning model to improve students' learning outcomes on plane figures. Using a Research and Development approach with the 4-D model implemented up to the Develop stage, the results indicate that the developed ELKPD meets the criteria of validity, practicality, and effectiveness. Expert validation using Aiken's V showed high validity, while teacher and student response questionnaires demonstrated high practicality. The effectiveness of the ELKPD was evidenced by improved learning outcomes based on pre-test and post-test analysis supported by a high N-gain score. A methodological limitation of this study is that the development process was conducted only up to the Develop stage of the 4D model. As a result, the findings demonstrate the feasibility and effectiveness of the ELKPD only within a limited context. The absence of the Disseminate stage means that the product has not yet been tested across different schools, regions, or student characteristics. Therefore, while the results are promising, further studies are required to implement the dissemination stage to examine the adaptability, sustainability, and generalizability of the ELKPD in broader educational settings.

Despite these positive findings, the effectiveness evaluation employed a one-group pre-test–post-test design without a control group, and the development process was limited to the Develop stage of the 4-D model. Therefore, the generalization of the findings is restricted to contexts with similar characteristics to the research setting.

The main contribution of this study lies in the integration of Discovery Learning principles into a Flipbook-assisted ELKPD that functions as a digital instructional scaffold rather than a static worksheet. This integration supports active student engagement, independent learning, and conceptual understanding in junior high school mathematics learning.

Future research is recommended to implement the Disseminate stage across different schools and regions and to employ experimental or quasi-experimental designs with control groups to strengthen external validity and support broader adoption of the developed ELKPD.

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