

## DEVELOPING SCRATCH GAME INTEGRATED INTERACTIVE E-LKPD TO MEASURE JUNIOR HIGH STUDENTS' MATHEMATICS COMPREHENSION

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### ABSTRACT

Students' mathematical conceptual understanding at the junior high school level remains relatively low, while learning media specifically designed to assess this ability are still limited. In addition, mathematics learning is often less varied, passive, and lacks the integration of technology-based educational games. This study aimed to develop an interactive Electronic Student Worksheet (E-LKPD) integrated with Scratch games to assess and enhance students' mathematical conceptual understanding. The study employed a Research and Development (R&D) approach using the Borg and Gall development model, which consists of nine stages: preliminary study, research planning, product design development, preliminary field testing, initial product revision, main field testing, further product revision, operational field testing, and final product revision. The research was conducted at SMPN 18 Serang City, involving 40 eighth-grade students selected through purposive sampling. Data were collected using expert validation questionnaires, student response questionnaires, and a mathematical conceptual understanding test. The results indicated that the developed E-LKPD achieved a validity score of 83% from material experts and 85% from media experts, both categorized as highly valid. The practicality test based on students' responses yielded a score of 76%, indicating that the product was practical. Furthermore, the effectiveness test resulted in a score of 83%, categorized as effective. These findings demonstrate that the Scratch-integrated interactive E-LKPD meets the criteria of validity, practicality, and effectiveness, making it suitable for use as both a learning medium and an assessment tool for measuring junior high school students' mathematical conceptual understanding.

**Keywords:** conceptual understanding skills; E-LKPD; interactive; scratch.

### ABSTRAK

Kemampuan pemahaman konsep matematika siswa SMP masih tergolong rendah, sementara media pembelajaran yang secara khusus digunakan untuk mengukur kemampuan tersebut belum banyak tersedia. Selain itu, pembelajaran matematika cenderung kurang bervariasi, bersifat pasif, dan belum memanfaatkan teknologi yang terintegrasi dengan permainan edukatif. Penelitian ini bertujuan mengembangkan E-LKPD interaktif yang terintegrasi game Scratch untuk mengukur sekaligus meningkatkan kemampuan pemahaman konsep matematika siswa SMP. Penelitian menggunakan metode Research and Development (R&D) dengan model Borg & Gall yang meliputi sembilan tahap, yaitu studi pendahuluan, perencanaan penelitian, pengembangan desain produk, uji coba lapangan awal, revisi awal produk, uji coba lapangan utama, revisi lanjutan produk, uji coba lapangan operasional, dan revisi akhir produk. Penelitian dilaksanakan di SMPN 18 Kota Serang dengan sampel sebanyak 40 siswa kelas VIII yang dipilih menggunakan teknik purposive sampling. Data dikumpulkan melalui angket validasi ahli, angket respons siswa, dan tes kemampuan pemahaman konsep matematika. Hasil penelitian menunjukkan bahwa E-LKPD yang dikembangkan memperoleh tingkat validitas sebesar 83% dari ahli materi dan 85% dari ahli media dengan kategori sangat valid. Hasil uji kepraktisan berdasarkan respons siswa memperoleh persentase sebesar 76%

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*dengan kategori praktis. Adapun hasil uji keefektifan menunjukkan persentase sebesar 83% dengan kategori efektif. Temuan ini menunjukkan bahwa E-LKPD interaktif terintegrasi game Scratch memenuhi kriteria valid, praktis, dan efektif sehingga layak digunakan sebagai media pembelajaran sekaligus instrumen untuk mengukur kemampuan pemahaman konsep matematika siswa SMP.*

**Kata kunci:** E-LKPD; interaktif; kemampuan pemahaman konsep; scratch.



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## Introduction

In today's digital age, technological advancements have emerged across various aspects of life, particularly in education. Technology can support a more effective and interactive learning process (Ambarwati et al., 2022). Mathematics is an essential subject to study. However, mathematics is generally still perceived as difficult to grasp due to the complexity of the concepts studied, as well as students' conceptual misunderstandings during the learning process. This situation is reinforced by research at (Jeheman, Gunur, & Jelatu 2019), which highlights that, at present, students' conceptual understanding of mathematics is not yet fully developed.

The low level of students' mathematical conceptual understanding in Indonesia can be seen from the PISA scores, where mathematics scores reached only 366 in 2022, compared to 379 in 2018 (OECD, 2022). In addition to the PISA results, other data such as TIMSS indicate that Indonesia's ranking has declined (Hamzah, Turmudi, & Dahlan, 2023). In a presentation by (Hadi & Novaliyosi, 2019), it was noted that Indonesia's 2019 TIMSS results showed an average score of 397, indicating that, on average, students were not yet capable of applying mathematical concepts that are considered complex and abstract; furthermore, students were less able to communicate these concepts and relate them to other topics. Evidence from the field is also supported by research conducted by the National Centre for Educational Research and Development (Masturah, Zubaidah, & Khairunnisak, 2021), which highlights that Indonesia's TIMSS score is below 500, meaning students' abilities are categorised as low standard. This data measures students' overall abilities across Indonesia but does not provide specific measurements for particular regions or schools. In this regard, teachers as educators need to design effective and efficient learning tools to help students understand the concepts of the subject matter (Anriani, Hidayat, & Setiani 2020). According to (Fobia, Nenohai, & Nubatonis, 2023), their research explains that the optimal use of learning media is beneficial in helping students understand the subject matter. Optimizing the use of interactive media can improve learning outcomes (Sudarman & Vahlia, 2021).

A similar issue was also identified at SMPN 18 Kota Serang; data collected through interviews with mathematics teachers indicated that students' abilities in mathematics learning are still considered low based on observation, particularly regarding the SPLDV material. Students tend to have a poor understanding of basic algebraic operations and struggle to determine problem-solving methods. Furthermore, students appear less active and less engaged during the learning process.

To address these issues, an interactive learning medium is required that can help students understand mathematical concepts more effectively through the

creation of interactive E-LKPDs. To make learning more engaging, the E-LKPDs are integrated with the *Scratch* game. *Scratch* was chosen because it features an interactive interface and is user-friendly, thereby helping students grasp mathematical concepts through more engaging learning activities (Sudihartinih, Novita, & Rachmatin 2021). Interactive learning media has the potential to increase students' motivation, independence, and learning outcomes in mathematics learning (Syakinnah et al., 2026).

Several international studies have shown that game-based digital learning media can improve students' understanding of mathematical concepts. (Chang & Hwang, 2019) states that game-based learning can motivate students to understand concepts through active and contextual learning. However, previous research has generally focused only on the use of digital games in mathematics learning in general. This study, however, focuses on the development of an interactive E-LKPD integrated with the *Scratch* game to measure the mathematical concept comprehension abilities of Year 8 students at SMPN 18 in Serang City.

### Research Method

This study employed the Research and Development (R&D) method using the Borg & Gall development model, which comprises nine stages: preliminary study, research planning, product design development, initial field trial, initial product revision, main field trial, further product revision, operational field trial, and final product revision (Gall, & Borg, 2003). The tenth stage, namely dissemination and implementation, was not carried out due to time constraints and the scope of the research. The main objective was focused on product development and testing on a limited scale. The research stages carried out are presented in Figure 1 below.

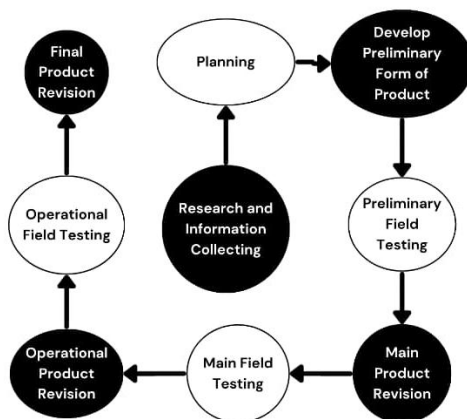


Figure1 . Research Procedure

The research subjects consisted of 3 expert validators and 40 Year 8 pupils at SMPN 18, Serang City. The validators comprised 3 subject matter experts and 3 media experts with expertise in mathematics education and digital media development. Pupil respondents were selected using purposive sampling in accordance with the research requirements for the SPLDV material.

The data collection techniques employed included semi-structured interviews with mathematics teachers, questionnaires, and tests. The

questionnaires comprised subject matter and media expert validation questionnaires to determine the product's validity, as well as student response questionnaires to assess its practicality. The effectiveness of the product was measured through a test of mathematical concept comprehension based on concept comprehension indicators in the SPLDV material. Prior to use, the research instruments were validated and revised based on the expert validators' suggestions. Data analysis was conducted using the ' ' method, calculating the validity, practicality, and effectiveness scores of the product using the following formula.

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

These were then interpreted according to the predetermined criteria presented in Table 1, Table 2, Table 3, and Table 4.

Table 1. Validity Criteria

Percentage (%)	Criteria
80 < Score ≤ 100	Highly Valid
60 < Score ≤ 80	Valid
40 < Score ≤ 60	Fairly Valid
20 < Score ≤ 40	Less Valid
0 < Score ≤ 20	Invalid

Table 2. Practicality Criteria

Percentage (%)	Notes
< 21	Very Impractical
21 - 40	Not very practical
41-60	Fairly Practical
61-80	Practical
81-100	Very Practical

Source: (Riduwan & Akdon 2013)

In Table 1, the validity of the research instrument is classified into five categories based on the percentage score obtained. Scores between 80% and 100% are deemed highly valid (ready for use), while scores from 60% to 80% are considered valid (eligible with minor refinements). The range of 40% to 60% indicates a fairly valid instrument that requires noticeable revision, whereas scores from 20% to 40% are less valid and need major restructuring. Any score below 20% is classified as invalid, making the instrument entirely unsuitable. Conclusively, a higher percentage score reflects greater precision and reliability in the research tool.

In Table 2, the practicality of the research instrument is categorized into five levels based on the percentage score achieved. Scores between 81% and 100% are classified as very practical, while scores from 61% to 80% are considered practical, both indicating high usability. The range of 41% to 60% represents a fairly practical instrument that meets baseline requirements but may need adjustments. Conversely, scores from 21% to 40% are deemed not very practical, and any score below 21% is categorized as very impractical, signaling severe limitations in implementation. Ultimately, a higher percentage score demonstrates greater efficiency, ease of use, and overall feasibility of the instrument in the research process.

Table 3. Criteria for Students' Proficiency Levels of Students through Tests

Score Interval	Category
0-60	Low
61-75	Medium
76-100	High

Table 4. Effectiveness Criteria

Percentage	Interpretation
>75	Effective
56-75	Moderately effective
40 - 55	Less effective
<40	Ineffective

Source: (Miftaqlzanah, 2021)

Source: (Sukarelawan et al., 2024)

In Table 3, the assessment results are classified into three distinct categories based on the score intervals obtained. Scores ranging from 76 to 100 are classified as high, indicating an excellent level of achievement or optimal results. Score within the 61 to 75 range fall into the medium category, representing a moderate or average level of performance that meets acceptable standards. Conversely, any score from 0 to 60 is deemed low, signaling a sub-optimal outcome that requires significant improvement. In short, a higher score interval directly corresponds to a higher level of achievement within the evaluated criteria.

In Table 4, The effectiveness of the evaluated instrument or intervention is classified into four distinct levels based on the percentage score achieved. Scores exceeding 75% are interpreted as effective, demonstrating a high level of success and optimal performance. Scores within the 56% to 75% range are considered moderately effective, indicating satisfactory results that meet the necessary standards with room for minor improvements. Conversely, scores from 40% to 55% are deemed less effective, signaling limited impact, while any score below 40% is classified as ineffective, representing a failure to meet the intended objectives. Conclusively, a higher percentage score directly reflects a greater degree of efficiency and success in achieving the desired outcomes.

## Results and Discussion

The preliminary study in this research was obtained based on information gathered through a literature review regarding the relevance of previous research and the results of interviews with teachers at SMPN 18 Kota Serang. Based on the results of the literature search and collection, the researcher found the *Scratch* platform, which can be used in the development of interactive E-LKPDs. In previous research (Pitaloka, 2024), the integration of *the Scratch* game was used as a form of game-based learning media in general; there was no specific focus on E-LKPDs. Consequently, there is an opportunity for the researcher to conduct research on the development of interactive E-LKPDs on the *Scratch* platform. As stated by (Moto 2019), the assessment of learning abilities is linked to the media used in the learning process, whether physical objects or the surrounding environment. Various types of media are outlined by (Saman, 2023). E-LKPD encompasses almost all types of media used. Referring to the opinion at (Azhari & Huda, 2022), it is explained that E-LKPD is a student work guide that facilitates conceptual understanding, packaged in electronic form for use with computers, laptops, smartphones, and similar

devices. Furthermore, E-LKPD can be developed interactively to create varied, interactive, and meaningful learning, as per the opinion at (Hasanah et al., 2025), which defines interactivity as an experience of direct student engagement.

The research planning stage was systematically organised, taking into account the urgent need for interactive learning that engages students' mathematical conceptual understanding. According to (Syamili, 2024), there is evidence of improved conceptual understanding resulting from the development of interactive E-LKPDs using wizer.me and Geogebra on the topic of flat-sided three-dimensional shapes. Meanwhile, previous research also developed worksheets using *Scratch*, aimed at improving students' computational thinking skills (Wikasari, Suweken, & Suparta, 2024). Unlike these two studies, this research develops an interactive E-LKPD integrated with the *Scratch* game, specifically designed to measure students' mathematical conceptual understanding.

The product design development stage is a follow-up to the planning stage, comprising the E-LKPD development process and assessment by expert validators to determine the validity of the E-LKPD development product. As indicated by (Yustina & Yahfizham, 2023), games can be engaging and provide a memorable experience in acquiring skills and understanding subject matter. The results of the design development are presented in Figures 2 to 12.



Figure 2 . Cover



Figure 3 . Home



Figure 4 . Terms & Conditions

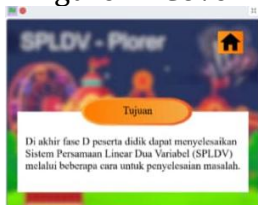


Figure 5 . Objectives



Figure 6 . Contact



Figure 7 . ID



Figure 8 . Map

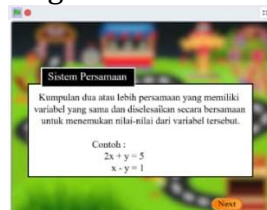


Figure 9 . Keywords

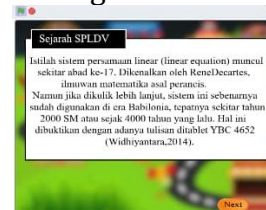


Figure 10 . History



Figure 11 . Learning Activities



Figure 12 . Reflection

Figure 2 shows the initial display or *cover* of the E-LKPD, Figure 3 shows the home screen or initial homepage, Figure 4 outlines the terms and conditions of use for the E-LKPD, Figure 5 explains the objectives of the E-LKPD, Figure 6 provides information about the creator of the E-LKPD, Figure 7 shows the user identity form for the E-LKPD, Figure 8 displays a map for using the E-LKPD, Figure 9 lists the keywords used in the E-LKPD, Figure 10 contains the history of SPLDV, Figure 11 shows learning activities, and Figure 12 shows reflection activities to consolidate the material studied.

The stage following the development of the E-LKPD is assessment by expert validators. Validation was carried out by three expert validators, comprising two mathematics education lecturers and a mathematics teacher from a school. These three validators served as subject matter experts and media experts. The results of the validators' assessment can be seen in Table 5.

Table 5. Results of the Expert Validators' Assessment

Validator	Content	Criteria	Media	Criteria
Expert 1	67%	Valid	68%	Valid
Expert 2	85%	Highly Valid	88%	Highly Valid
Expert 3	97%	Highly Valid	100%	Highly Valid
<b>Total</b>	<b>83%</b>	<b>Highly Valid</b>	<b>85%</b>	<b>Highly Valid</b>

Based on Table 5, it can be concluded that Expert Validator 1 scored 67% for content and 68% for media, meeting the 'valid' criteria. Expert Validator 2 scored 85% for content and 88% for media, meeting the 'highly valid' criteria. Expert Validator 3 scored 97% for content and 100% for media, meeting the 'highly valid' criteria. Thus, overall, the expert validators' assessment of the developed E-LKPD yielded 83% for content and 85% for media, meeting the 'highly valid' criteria. There were several suggestions and improvements regarding the comprehensive use of drag-and-drop techniques in learning activities using the substitution and

elimination methods. The results of the developed E-LKPD are presented in Figure 13 and revised in Figure 14.



Figure 13. Before revision



Figure 14. After revision

The results of the revision are evident in the arrangement of the initial display icons and the activation of the learning objectives, which were created on a single slide. The E-LKPD development process in this study was carried out using the 9-stage Borg & Gall development model. According to (Maydiantoro 2021), the advantages of this development model include the ability to produce a high-quality product and to motivate broad innovation in product development. The validity of the E-LKPD development was determined through an assessment process by expert validators using expert validation sheets for subject matter and media experts, comprising statement indicators, comments and suggestions as material for evaluation and improvement to further develop the E-LKPD product. The results of the validity test can be seen in Figure 13 below.

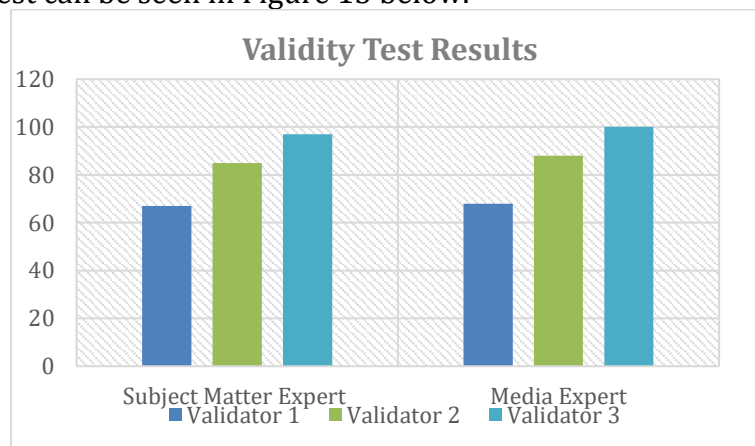


Figure 15. Validity Test Results

The practicality of the developed product was tested through two stages: an initial field trial and a main field trial. The initial field trial involved only six respondents as an initial assessment stage to determine the initial practicality of the E-LKPD development. The first stage of the trial received a rating of “very practical” and several suggestions were made for the subsequent trial, namely that learning should be conducted in groups given the insufficient technological facilities such as laptops, and that more detailed explanations regarding usage and the questions used should be provided. Consequently, several improvements were made by clarifying instructions and phrases that had not been understood. The results of the initial field trial are presented in Figure 14.

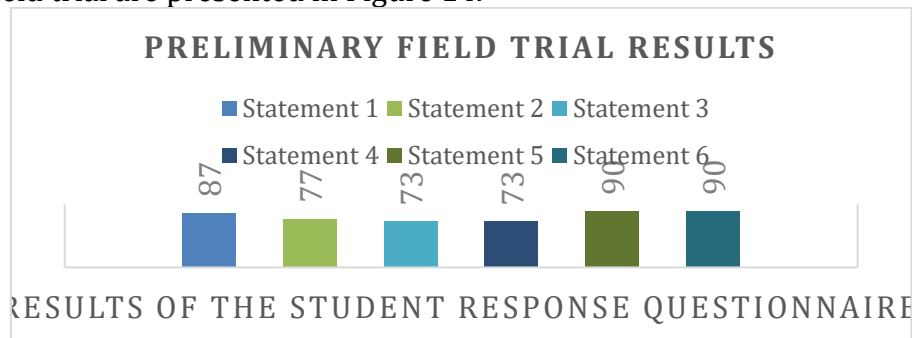


Figure 16. Results of the Initial Field Trial

From Figure 14, regarding the results of the initial field trial, it can be concluded that of the six statements in the student response questionnaire, statement 1 received a rating of 87%, statement 2 of 77%, statements 3 and 4 of 73%, and statements 5 and 6 of 90%. Thus, the highest scores were obtained by statements 5 and 6, which relate to interest in the appearance and colours of the developed E-LKPD. Meanwhile, the lowest scores were obtained from statements 3 and 4, which relate to the ease of the sentences and fonts used. Consequently, this serves as a basis for improvement for the researcher to maximise the development of the E-LKPD.

The second phase of the trial involved 40 respondents, with a score of 76% categorised as “practical” based on the criteria stated by (Riduwan and Akdon 2013). The use of the E-LKPD is considered practical if the practicality score reaches the average of the questionnaire responses (Sidik et al. 2023). The results obtained are a broad assessment of student questionnaire responses with a main field trial in one class, presented in the following graph:

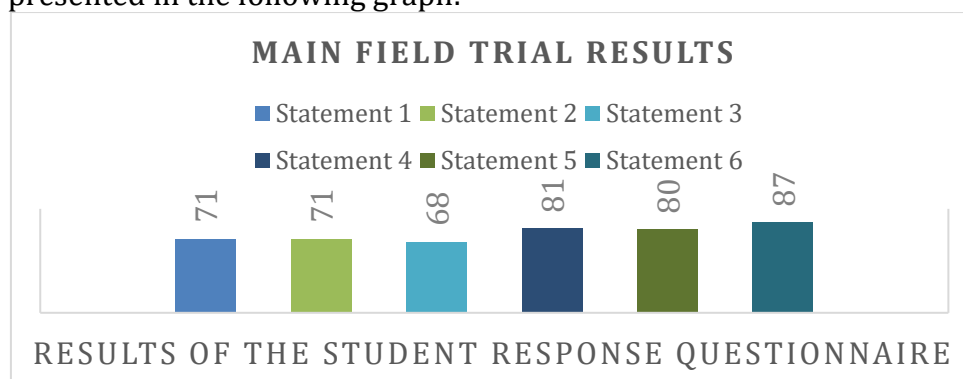


Figure 17. Results of the Main Field Trial

The results of the main field trial can be summarised as follows: of the six statements in the student response questionnaire, statements 1 and 2 received a rating of 71%, statement 3 68%, statement 4 81%, statement 5 80%, and statement 6 87%. Thus, the highest score was obtained by statement 6, which concerns interest in the colours of the developed E-LKPD. Meanwhile, the lowest score was obtained from statement 3, which concerns the ease of the sentences used.

The next objective in the development of this E-LKPD is to determine the effectiveness of the product developed. In line with the view that (Hantono and Lubis 2024) is a measure used to assess learning competence in accordance with educational regulations regarding the quality of the learning process. Effectiveness is determined based on the results of the conceptual understanding test administered during the operational field trial phase. The graph of the results of the conceptual understanding test is as follows:

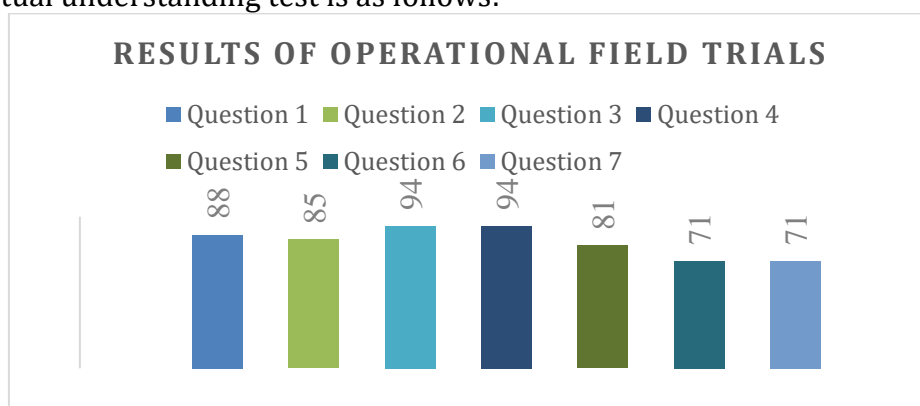


Figure 18. Results of the Operational Field Trial

The results of the operational field trial are based on research respondents who answered 7 questions in accordance with the concept comprehension indicators used by the researcher. The result obtained was 83%, falling into the 'effective' category. There were 5 indicators that met the criteria for a high level of concept comprehension ability, namely, questions 1 to 5. Question 1 scored 88%, question 2 scored 85%, questions 3 and 4 scored 94%, and question 5 scored 81%. Meanwhile, questions 6 and 7 scored 71%, falling into the moderate category. Thus, students' conceptual understanding of mathematics in the SPLDV material is categorised as high.

The final stage involved the final revision of the product. This revision was carried out taking into account suggestions from the research subjects, namely three expert validators and 40 respondents from Class VIII F at SMPN 18 in Serang City.

The research results indicate that the interactive E-LKPD integrated with the *Scratch* game is classified as highly valid, practical, and effective for use in teaching the mathematics curriculum at lower secondary level. The high level of validity indicates that the content, interface, and interactive features of the E-LKPD align with learning requirements and the indicators of students' mathematical concept comprehension. The practicality of the E-LKPD, which was rated as practical, indicates that the medium is easy for students to use in terms of its interface, navigation, and usage instructions. This is because the E-LKPD was designed with an interactive, game-based interface, thereby motivating students and encouraging their active participation during mathematics lessons. The use of the *Scratch* game

helps create a more meaningful and varied learning atmosphere. Testing of effectiveness levels shows that the E-LKPD is capable of effectively measuring students' mathematical concept comprehension. This is evident from their understanding of the subject matter, their ability to solve problems, and their ability to connect mathematical concepts with activities in the *Scratch* game interactively.

The findings of this study indicate that the development of an interactive E-LKPD integrated with *the Scratch* game not only functions as a learning medium but can also measure students' ability to understand mathematical concepts. This finding constitutes a significant contribution of the research, as the developed medium combines elements of assessment and learning within a single interactive platform. This aligns with previous research showing that the use of the educational game *Scratch* can motivate students to learn and understand mathematical concepts. However, this study differs from previous research as its focus is not only on the development of learning media but also on measuring students' mathematical concept comprehension through the interactive E-LKPD.

This study has several strengths, namely the interactive presentation of the media, the integration of engaging *Scratch* games, and the media's ability to assist in the evaluation of students' mathematical concept understanding. However, a limitation of this study is the small sample size within a single school, meaning the measurement results only cover that particular cohort.

The implications of this study are that interactive E-LKPD integrated with *Scratch* games can serve as an innovative alternative learning medium that assists teachers in creating varied, interactive, and meaningful mathematics lessons, whilst measuring students' mathematical concept comprehension more effectively and in line with developments in learning technology.

## **Conclusions and Recommendations**

The assessment of junior high school students' mathematical concept comprehension through the development of E-LKPD integrated with the *Scratch* game is deemed highly valid, practical, and effective. It is hoped that future research will further refine aspects of the E-LKPD in line with the indicators set as learning objectives, develop E-LKPDs incorporating other assessment methods, and adapt them to meet the needs of other subject materials. Through this research, it is hoped that teachers or educators will be able to implement various digital platforms to create teaching materials that support a varied, enjoyable, and non-monotonous mathematics learning process. For students, it is hoped that the E-LKPD products developed can be utilised for mathematics learning.

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