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Development of Deep Learning-Based Digital Student Worksheet to Improve Ninth Grade Junior High School Critical Thinking Skills

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Abstract: *This study aims to determine a Deep Learning-based Digital Student Worksheet to improve ninth grade junior high school students' critical thinking skills whether is valid, practical, and effective. This study employed the Research and Development (R&D) method using the ADDIE model, which consists of Analysis, Design, Development, Implementation, and Evaluation. The product was evaluated using test instruments and questionnaires involving material experts, media experts, one grade IX mathematics teacher at UPT SMP Negeri 17 Medan, and 30 students of class IX-4. The developed product focused on geometric transformation material. The results showed that the product met the highly valid criterion. This was indicated by the average scores of 83.33% for material validation, 87.33% for media validation, 91.66% for pretest validation, 91.66% for posttest validation, and 92.39% for teaching module validation. The product also met the highly practical criterion, as shown by the students' response questionnaire result of 89.42% and the teacher's response questionnaire result of 100%. In terms of effectiveness, the product met the effective criterion because 93.33% of students achieved the Learning Objective Achievement Criteria in the posttest. It also supported the improvement of students' critical thinking skills, as reflected in the posttest results for each indicator: interpretation 100%, analysis 100%, evaluation 84.79%, and inference 73.12%. Furthermore, the overall N-gain score was 0.85, categorized as high, while the N-gain scores for each indicator were also in the high category. Therefore, the developed product was determined to be valid, practical, and effective. This digital student worksheet is recommended as an alternative mathematics learning tools that can support mindful, meaningful, joyful, and critical thinking-oriented learning at the junior high school level.*

Keywords: *ADDIE, critical thinking skills, deep learning approach, digital student worksheet*

INTRODUCTION

Education is the main foundation for developing superior and competitive human resources in the global era (Sanga & Wangdra, 2023). Law Number 20 of 2003 concerning the National Education System emphasizes that education is a conscious and planned effort to create a learning atmosphere and learning process that enables students to actively develop their potential. Within the framework of national development, education plays a strategic role in educating the nation and preparing a generation that is ready to face future challenges. Mathematics is a universal science that forms the basis for the development of modern technology and plays an important role in various disciplines and everyday life (Astuti, 2018). More than just a tool for problem solving, mathematics also serves as a vehicle for developing logical, analytical, systematic, critical, and creative thinking skills (Siahaan & Surya, 2020). according to Permendiknas No. 22 of 2006, one of the objectives of mathematics in primary and secondary education is for students to have the ability to think logically, analytically, critically, creatively, and independently. Twenty-first-century learners must not only master basic knowledge, but also be equipped with higher-order thinking skills, critical thinking, collaboration skills, and digital literacy (Cynthia & Sihotang, 2023).

These demands are in line with global competencies that emphasize the mastery of 21st-century skills or 4Cs, namely Critical thinking, Communication, Collaboration, and Creativity (Arnyana, 2019). Furthermore, Ministry of Education Regulation No. 21 of 2016 concerning basic and secondary education content standards regulates several elements that must be included in mathematics learning competencies. One of these is demonstrating critical reasoning, processing, and presentation skills in core competencies for basic to secondary education levels. As stated in the decision of *Badan Standarisasi Kurikulum dan Penilaian Pendidikan* No. 009/H/KR/2022, the Pancasila Student Profile contains 6 dimensions of Pancasila Student character, one of which is critical reasoning (Rizki et al., 2024). The implementation of the Kurikulum Merdeka aims to increase student active involvement and higher-order thinking skills (A'izah & Dewi, 2024). Critical thinking skills play a very important role in mathematics learning because they enable students to not only understand concepts procedurally, but also analyze, evaluate, and connect mathematical ideas in depth (Herman et al., 2024). Through critical thinking, students are able to interpret problems, identify relationships between concepts, and consider various solution strategies before making the right decision (Shanti et al., 2017). Furthermore, critical thinking in mathematics fosters a reflective attitude, curiosity, and the ability to evaluate the correctness of a solution, so that learning does not stop at simply finding answers, but develops into a more meaningful and problem-solving oriented process (Anggara, 2022).

However, the high demands of the mathematics curriculum are not in line with the reality on the ground. The low critical thinking skills of Indonesian students can be seen in the low results of the 2018 Programme for International Student Assessment (PISA) study, which shows that Indonesia still ranks 72nd out of 78 participating countries with an average score of 379 in mathematics (FactsMaps, 2019). Furthermore, the results of the 2022 Programme for International Student Assessment (PISA) study show that Indonesia ranks 69th out of 81 participating countries with a score of 366 (FactsMaps, 2023). The results of a study from another international institution, the Trends in International Mathematics and Science Study (TIMSS) 2015 in mathematics, show that Indonesia ranks 44th out of 49 participating countries (Muhtadin et al., 2024). From these results, it can be concluded that the mathematics learning and questions applied in Indonesia differ from international standards, so that students are not yet familiar with TIMSS and PISA standard questions that require critical thinking to solve them.

This is also confirmed by research conducted by Zebua et al. (2024), which shows that the average critical thinking ability of students is low, with an average score of 42.95. Each indicator of critical thinking ability, such as interpretation, analysis, evaluation, inference, explanation, and self-regulation, shows varying scores, but remains in the low category. Then, based on the research data by Susilawati et al. (2024), it was found that 21% of students had moderate critical thinking skills, 64% of students had low critical thinking skills, and 15% of students had very low critical thinking skills. This was also found in observations and interviews conducted on September 24, 2024, at UPT SMP Negeri 17 Medan, where it was found that the critical thinking skills of ninth-grade students were still relatively low. This was evident from the passive, teacher-centered learning process, which did not give students the opportunity to explore ideas, ask questions, or develop independent reasoning. Teachers also still use conventional learning models dominated by teacher and exercises, while the teaching materials used are only printed books without any variation in learning that can stimulate higher-level thinking activities. In addition, there are no digital student worksheets available to support interactive learning and encourage active student participation. In addition to these findings, various other studies also indicate, as in Ismaimuza's book (2025), that students' weak critical thinking skills in mathematics learning often

make it difficult for them to understand abstract concepts and tend to memorize procedures without really understanding the reasons behind the steps taken to solve problems.

This results in their low ability to relate one concept to another. Another problem that arises is students' low ability to interpret non-routine problems that require analytical thinking, as well as their lack of courage to raise critical arguments or questions in the learning process (Rahmadani, 2024). This condition is also exacerbated by a learning pattern that is still predominantly teacher-centered. Teachers often emphasize procedural problem solving rather than providing space for students to explore ideas, discuss, or find alternative solutions (Simbolon et al., 2022). This indicates that critical thinking skills play a very important role in education. In this study, students' critical thinking skills were measured using four indicators adapted from Facione (2017), namely interpretation, analysis, evaluation, and inference, which respectively refer to students' ability to identify the information asked in the problem, relate mathematical concepts, solve problems systematically, and draw logical conclusions based on the given problem. To bridge the gap between abstract geometric transformation concepts and students' low critical thinking skills, a learning approach that emphasizes cognitive depth, conceptual connection, and active reasoning is required. Therefore, the deep learning approach is considered relevant as a solution to support students in mathematical critical thinking more mindfully, meaningfully and joyfully.

The deep learning approach in education is a learning strategy that focuses on deep conceptual understanding, rather than simply memorizing procedures or superficial information (Fatmawaty, 2024). Unlike surface learning, which emphasizes quick mastery for short-term goals, deep learning encourages learners to connect new knowledge with existing knowledge, analyze the relationships between concepts, and reflect on the understanding they have gained (Epik et al., 2025). Abdul Mukti, Indonesia's Minister of Primary and Secondary Education, emphasizes a "deep learning" approach that integrates three main components: mindful learning, meaningful learning, and enjoyable learning (Wahyuni in Sujinem, 2025). Based on a literature study conducted by Feriyanto, F., & Anjariyah (2024) meaningful learning helps students connect new knowledge with their prior knowledge, experiences, and real-life contexts so that the material can be understood more deeply, mindful learning emphasizes students' full attention, active engagement, and awareness in understanding, analyzing, and reflecting on the material being learned, and joyful learning creates a positive, enjoyable, and engaging learning atmosphere that encourages students to be more motivated, enthusiastic, and actively involved in the learning process. This process trains students to evaluate, compare, and integrate information before drawing logical conclusions. In other words, deep learning not only strengthens mathematical understanding but also makes students active knowledge builders, while teachers act as facilitators who guide higher-order thinking processes (Nadawina et al., 2025). In mathematics education, the application of this approach allows students to not only solve problems procedurally, but also explore the reasoning behind a concept, ask reflective questions, and investigate various alternative solutions.

Digital Student Worksheets (LKPD) are an enhanced version of conventional technology-based student worksheet, designed to present learning materials and assignments interactively through digital devices (Rahmayani & Atmazaki, 2025). Digital student worksheet is an evolution of conventional student worksheet developed by utilizing digital technology to provide a more interactive, interesting, and effective learning experience (Siregar et al., 2024). Digital student worksheet can be equipped with multimedia elements such as animations, videos, simulations, and gamification, which make learning more interesting and interactive (Fitrianingsih et al.,

2025). In addition, the application of digital student worksheet can be in line with the deep learning approach, which emphasizes a deep understanding of concepts, not just memorizing procedures. Through the interactive and multimedia features available, digital student worksheet is able to provide learning activities that encourage students to connect old knowledge with new concepts, explore the reasons behind an answer, and review various alternatives for solving problems.

This process greatly supports the development of critical thinking skills, as students are trained to interpret problems, analyze the interrelationships between concepts, evaluate solution strategies, and reflectively conclude results. Thus, the integration of digital worksheets and the deep learning approach can create a more meaningful, interactive learning experience that is oriented towards strengthening critical thinking skills in mathematics learning. Based on the above description, it can be concluded that the development of Deep Learning-Based Digital student worksheet to Improve Ninth Grade Junior High School Critical Thinking Skills is an urgent need that must be addressed immediately. The objective of this study is to determine how the product of a deep learning-based digital student worksheet to improve ninth grade junior high school students' critical thinking skills is valid, practical, and effective.

METHOD

This research was conducted at UPT SMP Negeri 17 Medan, located at Jl. kapten M Jamil Lubis No 108, Bandar Selamat, Kec. Medan Tembung, Kota Medan Prov. North Sumatra. The subjects in this study were students in class IX-4 at UPT SMP Negeri 17 Medan in the 2025/2026 academic year. Meanwhile, the object of this study was a web-based Digital Student Worksheet developed using the Liveworksheets platform and designed based on the deep learning approach on geometric transformation material. This type of research is research and development (R&D). The R&D method was chosen because it is in line with the research objectives, namely to produce a digital student worksheet product using a deep learning approach and to test the validity, practicality, and effectiveness of the product in improving students' critical thinking skills. This method not only focuses on product development but also ensures that the resulting product is valid, practical, and effective for use in the learning process (Rahayu, 2025).

The development model used as the basis for this research is the ADDIE development model. The ADDIE development stages consist of 5 stages, namely Analysis, Design, Development, Implementation, and Evaluation.

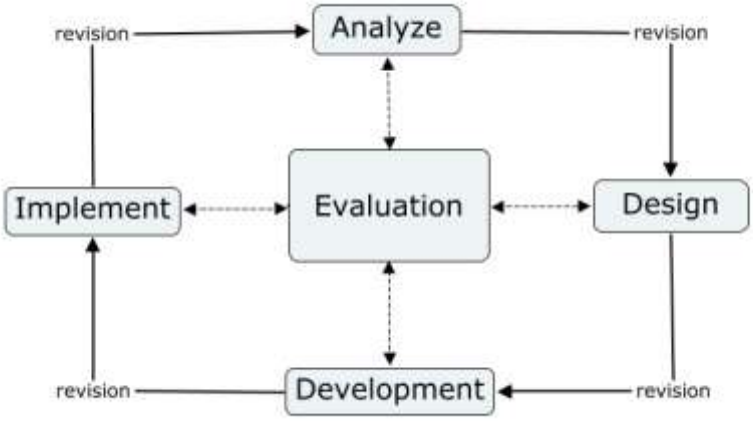

Figure 1. ADDIE model diagram

The data collection techniques used in this study were observation, interviews, validation sheets, questionnaires, and pre-test and post-test. The research instruments used in this study consisted of validation sheets, practicality questionnaires, and pretest-posttest instruments

After the scores are calculated, the percentage values can be adjusted according to the validation criteria presented in the table by Pattimura et al. (2020) below:

Table 1. Validation Criteria

Product Validity Percentage (Va)	**Criteria**
$80\% < Va \leq 100\%$	Highly Valid
$60\% < Va \leq 80\%$	Valid
$40\% < Va \leq 60\%$	Sufficiently Valid
$20\% < Va \leq 40\%$	Less Valid
$0\% < Va \leq 20\%$	Not Valid

Table 1 shows the category of product validity level based on the percentage of validator ratings. After that continue to practicality test. After the scores are calculated, the percentage values can be adjusted according to the practicality criteria presented in the table below:

Table 2. Practicality Criteria

Product Practicality Percentage (Ka)	**Criteria**
$80\% < Ka \leq 100\%$	Very Practical
$60\% < Ka \leq 80\%$	Practical
$40\% < Ka \leq 60\%$	Fairly Practical
$20\% < Ka \leq 40\%$	Less Practical
$0\% < Ka \leq 20\%$	Not Practical

Table 2 shows that digital LKPD is not only valid in theory but also practical in real use in the classroom. To determine the effectiveness of the deep learning-based digital LKPD that was developed, pretest and posttest questions were given to students, which were compiled in accordance with critical thinking skill indicators. Students are considered to have completed the learning objectives if their scores reach the Learning Objective Achievement Criteria (*Kriteria Ketercapaian Tujuan Pembelajaran*) threshold of ≥ 75%. Learning completeness using the following formula:

$$Completeness\ percentage = \frac{Number\ of\ students\ who\ passed}{Total\ Number\ of\ students} \times 100\%$$

The analysis of the improvement in students' critical thinking skills is seen as a whole according to the indicators of critical thinking skills. With critical thinking skills criteria referring to the following percentage criteria.

Table 3. Table of Critical Thinking Ability Indicator Criteria

Indicator Criteria (IC)	**Criteria**
$80\% < IC \leq 100\%$	Excellent
$60\% < IC \leq 80\%$	Good
$40\% < IC \leq 60\%$	Fair
$20\% < IC \leq 40\%$	Poor
$0\% < IC \leq 20\%$	Very Poor

Table 3 is used to classify students' critical thinking skills based on indicators. The improvement in critical thinking skills of students before and after using the digital student worksheet is calculated using the N-gain formula based on the average gain. The measurement results were adjusted to the criteria values by Khalil et al., (2022) as follows:

Table 4. N-gain Test Criteria

Boundary	Category
$g \geq 0{,}7$	High
$0{,}3 \leq g < 0{,}7$	Medium
$g < 0{,}3$	Low

Table 4 is used to compare the results of the pretest and posttest so that the effectiveness of the use of digital LKPD can be known.

RESULT AND DISCUSSION

At the analysis stage, performance, resource, needs, and material analyses were conducted to identify the conditions and requirements for developing the Deep Learning-based Digital Student Worksheet. The results showed that the learning process at UPT SMP Negeri 17 Medan was still passive and teacher-centered, with students having limited opportunities to explore ideas, ask questions, and develop independent reasoning. Although the school had adequate facilities such as classrooms, a library, laboratories, electricity, projectors, mathematics teachers, and printed learning resources, the available materials were still limited to textbooks and conventional worksheets that did not support interactive learning or the development of critical thinking skills. In addition, students showed low engagement in mathematics learning and experienced difficulties in understanding and applying geometric transformation concepts, particularly in interpreting problems, analyzing relationships among concepts, evaluating strategies and results, and making logical inferences. Therefore, these findings became the basis for developing a Deep Learning-based Digital Student Worksheet using the Liveworksheets platform to provide more interactive, structured, meaningful, mindful, and joyful learning in order to improve students' critical thinking skills.

At the design stage, the activities focused on preparing all components needed to develop the Deep Learning-based Digital Student Worksheet based on the results of the analysis stage. This stage included the preparation of research instruments and the design of the product. A teaching module was first developed as a guideline for creating the worksheet in accordance with the learning outcomes, learning objective flow, and formulated objectives on the topic of geometric transformation. In addition, pretest and posttest instruments were prepared based on critical thinking indicators, along with validation instruments and teacher and student response questionnaires to assess the validity, practicality, and effectiveness of the product. The Digital Student Worksheet itself was designed by organizing the product framework, selecting appropriate images and text, preparing the cover, introductory section, work instructions, learning activities, evaluation tasks, relevant YouTube videos, and interactive features such as drag-and-drop activities. The completed draft was then converted into PDF format and uploaded to the Liveworksheets platform so that it could be used as an interactive digital learning medium for students.

The development stage was carried out after the product had been designed based on the prototype produced in the design stage. In this stage, the Digital Student Worksheet was developed using the Liveworksheets website. The teaching module validation sheet was used to assess the validity of the teaching module, The following are the results of the validation of the three validators:

Table 5. Teaching module validity results

Aspect	Percentage
Identity	100%
Formulation of Learning Objectives	91,66%
Materials	91,66%
Selection of Learning Model Approaches	91,66%
Learning Activities	91,66%
Selection of Learning Resources	91,66%
Assessment of Learning Outcomes	91,66%
Total	92,39%
Criteria	Highly Valid

Based on the table 5, the average percentage score of the teaching module validation was 92.39%, which falls into the highly valid category. The material content of the Deep Learning-based Digital Student Worksheet developed to improve ninth-grade junior high school students' critical thinking skills was tested for validity by three experts. The following are the results of the validation of the three validators:

Table 6. Material validity results

Aspect	Percentage
Content Quality	83,33%
Accuracy of questions	83,33%
Proper use of grammar	83,33%
Deep Learning Approach Component	83,33%
Total	83,33%
Criteria	Highly Valid

Based on the table 6, the average percentage score of the material validation was 83.33%, which falls into the highly valid category. Media expert validation of the Digital Student Worksheet was conducted by three validators who served as media experts in developing a Digital Student Worksheet using Liveworksheets. The following are the results of the validation of the three validators:

Table 7. Media validity results

Aspect	Percentage
Core Components	87,5%
Content	85,83%
Interface	91,66%
Technology	83,33%
Total	87,33%
Criteria	Highly Valid

Based on the table 7, the average percentage score of the media validation was 87.33%, which falls into the highly valid category. The test instrument validation was conducted to assess the quality of the pretest and posttest questions with critical thinking skills indicators. The following are the results of the validation of the three validators:

Table 8. Pretest and posttest validity result

Aspect	Percentage	
	Pretest	Posttest
Questions	91,66%	91,66%
Construction	91,66%	91,66%
Language	91,66%	91,66%

Total	91,66%	91,66%
Criteria	Highly Valid	

Based on the table 8 above, the validation results conducted by three mathematics experts on the posttest instrument, which consisted of four questions, show that across the three assessed aspects, the pretest and posttest obtained a validity score of 91.66%, which falls into the very valid category.

At implementation stage, the Deep Learning-based Digital Student Worksheet assisted by Liveworksheets was implemented to test its practicality and effectiveness in the learning process. The implementation was carried out by distributing the Deep Learning-based Digital Student Worksheet assisted by Liveworksheets to 30 students of class IX-4 and one mathematics teacher at UPT SMP Negeri 17 Medan. The practicality test was conducted by distributing questionnaires to practitioners, namely the teacher and the students. The results of the data analysis of the students' response questionnaire on the practicality of the developed Deep Learning-based Digital Student Worksheet can be seen in the following table.

Table 9. Results of the student's practicality questionnaire analysis

Aspect	**Percentage**
Content	88,75%
Presentation	90,41%
Readability of language and image	87,70%
Physical appearance	88,61%
Usability	90,55%
Total	89,42%
Criteria	Very Practical

Based on the table 9 above, the results of the students' response questionnaire toward the Deep Learning-based Digital Student Worksheet reached 89.42%, based on responses from 30 respondents to 19 questions. The results of the data analysis of the teacher's response questionnaire on the practicality of the developed Digital Student Worksheet can be seen in the following table.

Table 10. Results of the teacher's practicality questionnaire analysis

Aspect	**Percentage**
Material Suitability	100%
Ease of Use	100%
Learning Time Efficiency	100%
Benefits	100%
Total	100%
Criteria	Very Practical

Based on the table 10 above, the percentage results of the teacher's response questionnaire were 100% for the aspect of material suitability, 100% for ease of use, 100% for learning time efficiency, and 100% for benefits. In this effectiveness analysis, a description was provided of the improvement in ninth grade junior high school students' critical thinking skills, as reflected in the students' average scores, the percentage of KKTP achievement, the improvement in each indicator, and the results of the gain calculation. The description of the percentage of classical student learning completeness can be seen in the following table.

Table 11. Media validity results

Aspect	Pretest		Posttest	
	Total of Students	Percentage	Total of Student	Percentage
Complete	1	3,33%	28	93,33%
Not Complete	29	96,66%	2	6,66%
Total	30	100%	30	100%
Criteria	Not Complete		Complete	

Furthermore, a class is considered complete if ≥ 80% of the students in the class achieve the KKTP score. Based on the posttest results, 28 out of 30 students achieved the KKTP score, resulting in a classical completeness percentage of 93.33%. Analysis of the completion of Critical Thinking Skills:

Table 12. Analysis of the completion of Critical Thinking Skills

Indicator	Pretest		Posttest	
	%	Criteria	%	Criteria
Interpretation	67,50%	Good	100%	Excellent
Analysis	30,00%	Fair	100%	Excellent
Evaluation	12,50%	Poor	84,79%	Excellent
Inference	6,25%	Very Poor	73,12%	Good

Based on the table 12 above, the achievement of students' critical thinking skill indicators was achieved after using the Deep Learning-based Digital Student Worksheet. In the interpretation indicator, the result reached 100%, which was categorized as Excellent. In the analysis indicator, the result also reached 100%, which was categorized as Excellent. In the evaluation indicator, the result reached 84.79%, which was categorized as Excellent. Meanwhile, in the inference indicator, the result reached 73.12%, which was categorized as Good. Overall, these findings indicate that the critical thinking skill indicators were achieved after the implementation of the Deep Learning-based Digital Student Worksheet. The overall improvement in students' critical thinking skills based on the obtained N-gain is as follows.

Table 13. Overall N-gain analysis

Category	Pretest	Posttest
Mean value	18,47	57,27
Overall N-Gain value	0,85	
Criteria	High	

Based on the table 13 above, the mean pretest score was 18.47, while the mean posttest score was 57.27. The overall N-gain value obtained was 0.85, which falls into the High category. This result indicates that the use of the Deep Learning-based Digital Student Worksheet showed a high level of effectiveness in terms of students' critical thinking skills. Therefore, it can be concluded that the improvement in students' critical thinking skills based on the overall N-gain was classified as high. The improvement in students' critical thinking skills for each indicator after using the Deep Learning-based Digital Student Worksheet is presented in the following table.

Table 14. N-gain analysis each indicator

Indicator	Pretest	Posttest	N-gain	Criteria
Interpretation	10,8	16	1	High
Analysis	4,8	16	1	High
Evaluation	2	13,56	0,82	High

Inference	1	11,7	0,71	High

Based on the table 14 above, the N-gain value for each indicator of students' critical thinking skills after using the Deep Learning-based Digital Student Worksheet was categorized as High. The interpretation indicator obtained an N-gain value of 1, which indicates a High category. The analysis indicator also obtained an N-gain value of 1 and was categorized as High. Furthermore, the evaluation indicator obtained an N-gain value of 0.82, which also fell into the High category, while the inference indicator obtained an N-gain value of 0.71, which was likewise categorized as High. Overall, these results show that the achievement of each critical thinking skill indicator after using the Deep Learning-based Digital Student Worksheet was in the High category. Therefore it can concluded that the product of deep learning-based digital student worksheet is improving ninth grade junior high school critical thinking skills. The high N-gain values in the interpretation and analysis indicators can be related to the interactive design of the Deep Learning-based Digital Student Worksheet.

Through visual representations, YouTube videos, drag-and-drop activities, and structured problem-solving tasks, students were guided to identify given information, understand what was asked, and analyze the relationships among geometric transformation concepts. These activities supported meaningful, mindful, and joyful learning because students actively connected concepts, reflected on their reasoning, and engaged with the material interactively. Therefore, the achievement of high N-gain in these indicators indicates that the worksheet features effectively supported students' interpretation and analysis skills in geometric transformation learning. Drawing conclusions was still the most difficult stage for students. This is because inference requires students not only to solve the problem correctly, but also to connect the results with the relevant concepts and formulate a logical conclusion. This finding is in line with Rahmawati et al. (2025), who found that students often had difficulty at the inference stage because they were not yet able to relate the available information to the appropriate mathematical concepts, which led to inaccurate conclusions.

The evaluation stage was the final stage in which revisions were made after receiving suggestions, comments, and feedback from students, the teacher, and the three validators. This stage was carried out to identify the weaknesses and errors found during the research and development process of the Deep Learning-based Digital Student Worksheet assisted by Liveworksheets. The findings of the present study are supported by several previous studies showing that interactive digital worksheets tend to meet the criteria of validity, practicality, and effectiveness while also supporting students' critical thinking skills. Subekti and Prahmana (2021) reported that interactive electronic student worksheets for junior high school mathematics developed through the ADDIE model were valid, very practical, and effective, with a significant difference between pretest and posttest scores and an N-gain of 0.43. Sugandi et al. (2024) also found that a problem-based e-LKPD assisted by Web Liveworksheet in mathematics achieved 88% validity, 82% practicality, and 86% effectiveness.

Similar findings were reported by Febryanti and Rusmini (2022), whose Liveworksheets-assisted e-LKPD was categorized as very valid and very practical and produced a critical thinking N-gain of 0.51 with a significant paired-sample test result. More recently, Nur'aini and Taufik (2025) showed that a Liveworksheet-based interactive worksheet for junior high school students also fulfilled the valid, practical, and effective criteria and obtained a critical thinking gain score of 0.665 in the effective category. Therefore, these previous studies reinforce the present finding that the Deep Learning-based Digital Student Worksheet assisted by Liveworksheets is an appropriate learning tool to support the achievement of students' critical thinking skills.

CONCLUSION AND SUGGESTION

Based on the results of the study, it can be concluded that the Deep Learning-based Digital Student Worksheet assisted by Liveworksheets was highly valid, highly practical, and effective in improving ninth grade junior high school students' critical thinking skills on the topic of geometric transformation. This was indicated by the high validation results for the teaching module, material, media, pretest, and posttest, as well as positive responses from both students and the teacher. Its effectiveness was shown by the high percentage of students who achieved the learning objective criteria, the achievement of each critical thinking indicator, and the overall high N-gain score. It is suggested that future studies include all critical thinking indicators, develop the worksheet for other mathematics topics, collect broader feedback, apply the product in different school contexts, and explore other educational technologies to enhance interactivity and student engagement.

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