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Development Of Deep Learning-Based Student Worksheets To Improve Critical Thinking Skills Of Senior High School Students

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Abstract

The low level of critical thinking skills among students in Geography learning, particularly on the topic of Regional Development, represents a fundamental challenge that requires immediate attention through the development of innovative and well-structured teaching materials. This study aimed to develop a deep learning-based Student Worksheet integrated with the Problem-Based Learning (PBL) model to improve the critical thinking skills of Grade XII senior high school students. The study employed a Research and Development (R&D) methodology using the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation). Research participants consisted of 20 Grade XII students from SMA Negeri 1 Suwawa Timur during the limited trial phase, and 81 Grade XII students distributed across four schools SMA Negeri 1 Tapa, SMA Negeri 1 Kabila, SMA Negeri 1 Bulango Ulu, and SMA Negeri 1 Bonepantai during the general trial phase. Data were collected through expert validation sheets, teacher and student response questionnaires, and essay-based critical thinking tests. Data analysis employed a descriptive quantitative approach, utilizing percentage calculations for validity and practicality assessments, and normalized gain (N-Gain) scores for effectiveness evaluation. The results indicated that the Student Worksheets satisfied the criteria for very high validity, as assessed by the content expert (97.7%) and the media expert (96.9%). Practicality was rated as very high, with teacher responses ranging from 92.5% to 98.8% and student responses ranging from 86.0% to 88.7%. Effectiveness was demonstrated through significant improvements in critical thinking skills, with N-Gain values

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ranging from 0.64 to 0.72, corresponding to moderate to high categories. Accordingly, the deep learning-based Student Worksheets developed in this study is declared valid, practical, and effective, and is therefore suitable for use as a teaching material in senior high school Geography instruction.

Keywords: deep learning, student worksheet, critical thinking, geography.

INTRODUCTION

Twenty-first century education demands that students possess the 4C competencies critical thinking, communication, collaboration, and creativity as essential preparation for navigating an increasingly complex global environment (Putri et al., 2023). Among the various competencies required in contemporary society, the ability to solve problems and think critically occupies a position of paramount importance. Critical thinking skills play a crucial role in enabling individuals to identify solutions to diverse challenges while simultaneously supporting the development of effective collaborative capacities (Khovivah et al., 2022).

Critical thinking holds a particularly significant position in Geography education, as this discipline not only emphasizes the mastery of spatial concepts but also requires students to develop a deep understanding of the relationship between human activity and the natural environment. According to Ennis, as cited in Hasanah et al. (2023), critical thinking is understood as the capacity to analyze, evaluate, and draw conclusions from information objectively and through logical reasoning. As'ari et al. (2024) further affirm that critical thinking in Geography education is essential for enabling students to analyze complex spatial phenomena, make informed decisions, and contribute effectively to social life.

Empirical evidence indicates that the critical thinking abilities of students in Indonesia remain at a low level. The 2022 Programme for International Student Assessment (PISA) results revealed that Indonesian students' critical thinking and problem-solving capabilities remain at a concerning level (Bilad et al., 2024). This condition is also reflected in learning outcomes at SMA Negeri 1 Suwawa Timur. Based on the 2025 Educational Report Card, the achievement of students' critical thinking skills declined by 1.41%, from 51.27% in 2024 to 49.86% in 2025. While this data reflects overall school-level assessment outcomes rather than Geography-specific measurements, it nonetheless provides an indication that students' critical thinking skills require improvement across all subject areas, including Geography. Furthermore, diagnostic test results on the Regional Development topic revealed that approximately 80% of students had yet to demonstrate optimal

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critical thinking performance, particularly with respect to the analytical and solution-generation dimensions.

These challenges were further corroborated by classroom observation findings, which indicated that instructional activities remained predominantly conventional and teacher-centered. Learning was largely dominated by the lecture method, resulting in severely limited opportunities for discussion, exploration, and contextual problem-solving activities. Consequently, students tended to remain passive and exhibited insufficient active engagement in the learning process. Moreover, the Student Worksheets employed by teachers had not been optimally designed; most contained only rote memorization exercises without the systematic instructional scaffolding necessary to cultivate students' critical thinking skills.

A deeper examination of classroom instructional practices revealed more fundamental root causes. Geography learning remained dominated by the lecture method, with minimal integration of discussion, exploration, and contextual problem-solving activities. Students tended to adopt a passive stance, receiving information without being prompted to question, analyze, or connect it to real-world phenomena. The Student Worksheets in use were not designed according to a structured pedagogical framework; their content was dominated by recall-based questions without coherent thinking progressions, learning resources were not integrated, and the visual presentation was insufficient to stimulate student learning interest.

These conditions stand in contradiction to the direction of national education policy as articulated in Ministerial Regulation of Primary and Secondary Education No. 13 of 2025, which underscores the importance of active, meaningful learning oriented toward strengthening students' critical thinking capabilities. Within this policy framework, the deep learning approach constitutes one of the primary foundations for implementing the Merdeka Curriculum. In the context of education, the concept of deep learning differs from its technical meaning in artificial intelligence; it refers to an instructional process that moves students beyond surface-level memorization (surface learning) toward deep, reflective, and applicable understanding (Brenya, 2024). This approach is grounded in three core principles: mindful (conscious engagement in thinking), meaningful (connection to real-life contexts), and joyful (a stimulating and curiosity-driven learning environment) (Suyanto, 2025). These three principles collectively create the cognitive and emotional conditions conducive to the development of critical thinking skills.

This approach is operationalized through Problem-Based Learning (PBL), which was selected as the most appropriate pedagogical model for this purpose (Aristin et al., 2023). PBL positions authentic problems as the primary stimulus for learning, thereby encouraging students

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to investigate, analyze, collaborate, and draw logical conclusions (Adilah & Rosyida, 2024). Multiple studies have demonstrated that PBL implementation is effective in improving critical thinking skills, particularly when integrated with interactive digital learning media (Nabilah & Syamsurizal, 2024).

The optimization of the deep learning approach and PBL model in this study was realized through the development of Student Worksheets. Student Worksheets were selected as the instructional medium because they have the capacity to support active, systematic, and contextual student learning. Aries et al. (2022) explain that Student Worksheets function as instructional guides that assist students in achieving learning competencies independently. Furthermore, Sari & Okmarisa (2023) assert that a well-designed Student Worksheets can enhance learning interaction and encourage students to think more critically and creatively.

A review of the current literature reveals several limitations in existing research on the development of deep learning-based Student Worksheets. First, most studies remain focused on product validation stages without comprehensively examining practicality or effectiveness in actual classroom settings (Saputri & Wulandari (2025); Rohmah & Murtini (2025)). Second, prior research has predominantly been conducted at the elementary and junior high school levels and has rarely been applied to Geography instruction at the senior high school level (Noperman et al. (2025); Chosya & Takiddin (2025)). Third, the majority of studies have focused on improving general literacy or higher-order thinking skills (HOTS), while the development of critical thinking through the integration of deep learning and Problem-Based Learning (PBL) remains limited.

This study was conducted to address these gaps through three primary contributions. First, the development of a deep learning-based Student Worksheets was carried out comprehensively using the ADDIE model, encompassing the full cycle from product validation and practicality assessment to effectiveness evaluation. Second, the developed Student Worksheets was specifically designed for Grade XII senior high school Geography instruction on the Regional Development topic, integrating the deep learning approach, Problem-Based Learning (PBL) model, QR code features, and digital flipbook technology in a cohesive manner. Third, this study is grounded in Permendikdasmen No. 13 of 2025 as the most recent regulatory framework that positions deep learning as a foundational basis for curriculum development, thereby ensuring the study's strong relevance to contemporary educational policy.

In light of these considerations, the development of a deep learning-based Student Worksheets to improve the critical thinking skills of senior high school students represents an urgently needed initiative. The product developed in this study is expected to demonstrate high

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quality in terms of validity, practicality, and effectiveness, while contributing to the realization of meaningful Geography learning that is aligned with both the Merdeka Curriculum and the demands of 21st-century education.

METHODS

This study employed a Research and Development (R&D) approach using the ADDIE model, which encompasses five stages: Analysis, Design, Development, Implementation, and Evaluation (Rustandi & Rismayanti, 2021). The ADDIE model was selected for its systematic, iterative, and needs-based nature, which allows for incremental revision based on validation data prior to field implementation. The study was conducted in Bone Bolango Regency, Gorontalo Province, from November 2025 to January 2026. The limited trial was conducted at SMA Negeri 1 Suwawa Timur (November–December 2025), while the general trial was carried out at SMA Negeri 1 Tapa, SMA Negeri 1 Kabila, SMA Negeri 1 Bulango Ulu, and SMA Negeri 1 Bonepantai (January 2026).

Development Procedure

The Analysis stage involved a comprehensive instructional needs assessment covering problem analysis, curriculum analysis, student characteristics analysis, product needs analysis, and school context analysis. Problem analysis was conducted through instructional reflection, document review, and diagnostic testing of students' critical thinking skills. The analysis results revealed that students' critical thinking abilities remained low, instruction was still predominantly lecture-based, and the Student Worksheets in use had not been designed to support the development of critical thinking skills. Curriculum analysis was conducted by examining the Grade XII Phase F Geography learning objectives under the Merdeka Curriculum, leading to the selection of Regional Development as the focus for product development.

The Design stage involved the construction of an initial product design for the deep learning-based Student Worksheets. At this stage, the Student Worksheets structure was developed to include sections for student identification, learning objectives, learning activities, worksheets, reflective exercises, and formative assessments. Learning activities were designed in accordance with the deep learning instructional sequence comprising the stages of understanding, applying, and reflecting and were integrated with the Problem-Based Learning (PBL) model. Research instruments were also developed at this stage, including the content expert validation sheet, media expert validation sheet, teacher and student response questionnaires, and the critical thinking skills assessment.

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The Development stage involved the realization of the product design into a fully operational Student Worksheets. The developed product was subsequently validated by content and media experts. Content expert validation assessed the alignment of material with learning objectives, conceptual accuracy, content completeness, application of deep learning principles, and the relevance of learning activities to students' critical thinking skills development. Media expert validation evaluated aspects of visual design, readability, layout, and clarity of instructions within the Student Worksheets. The product development process proceeded through iterative rounds of validation; content expert validation involved three revision cycles, while media expert validation involved two revision cycles. Each revision was conducted based on feedback and recommendations from the validators to refine the product until the Student Worksheets satisfied the established criteria for suitability and was declared ready for classroom implementation.

The Implementation stage was carried out in two phases: the limited trial and the general trial. The limited trial was conducted at SMA Negeri 1 Suwawa Timur to obtain preliminary data on the product's practicality and effectiveness. Subsequently, the general trial was conducted at SMA Negeri 1 Tapa, SMA Negeri 1 Kabila, SMA Negeri 1 Bulango Ulu, and SMA Negeri 1 Bonepantai to assess the Student Worksheets effectiveness in improving students' critical thinking skills across a broader and more diverse school context. Data were collected through teacher and student response questionnaires and a critical thinking skills assessment administered as pretest and posttest.

The Evaluation stage was conducted in both formative and summative forms. Formative evaluation was performed at each stage of development as the basis for product refinement, based on validator feedback and implementation outcomes. Summative evaluation was conducted to assess the final quality of the product across the dimensions of validity, practicality, and effectiveness, thereby yielding a deep learning-based Student Worksheets suitable for use in senior high school Geography instruction.

Instruments and Data Collection Techniques

The validity instruments consisted of content expert and media expert validation sheets, each employing a four-point Likert Scale (1 = strongly unsuitable, 2 = unsuitable, 3 = suitable, and 4 = very suitable) ((Sugiyono, 2013)). The content expert validation sheet comprised nine indicators covering the alignment of material with Learning Objectives, the inclusion of deep learning principles, support for critical thinking development, systematic structure consistent with PBL syntax, clarity of instructions, and appropriateness of language. The media expert validation

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sheet comprised 13 indicators organized into the dimensions of construction and visual presentation.

The practicality instruments consisted of teacher and student response questionnaires, both utilizing a four-point Likert Scale. The teacher response questionnaire addressed four evaluative dimensions: content, language, presentation and technical aspects, and implementation and feasibility. The student response questionnaire addressed four dimensions: content and material, language, visual presentation, and learning activities and engagement.

The effectiveness instrument consisted of a critical thinking skills assessment comprising 10 essay questions. The items were developed based on Ennis's (1984, as cited in Fitriyanti et al. 2025) five critical thinking dimensions: elementary clarification, basis for decision-making, inference, advanced clarification, and strategies and tactics. The instrument was validated by the content expert, and its reliability was subsequently assessed using Cronbach's Alpha coefficient with the assistance of IBM SPSS software. An instrument was considered reliable if it obtained a Cronbach's Alpha value above 0.70, indicating acceptable internal consistency (Yusup, 2018). The reliability coefficient obtained was 0.712, confirming that the instrument was reliable.

Data Analysis Techniques

The validity level of the deep learning-based Student Worksheets was analyzed using a descriptive quantitative approach applied to assessment data provided by the content and media experts. The validity percentage was calculated using the following formula:

$$\textit{Validity Percentage} = (\Sigma \textit{ Score Obtained} / \Sigma \textit{ Maximum Score}) \times 100\%$$

Where:

Σ Score Obtained = Total cumulative score from all validators

Σ Maximum Score = Highest achievable total score

The values obtained from this calculation were then categorized qualitatively as shown in Table 1.

Table 1. Validity Criteria for the Deep Learning-Based Student Worksheets

No	Interval (%)	Criteria
1	81 – 100	Very Valid
2	61 – 80	Valid
3	41 – 60	Sufficiently Valid
4	21 – 40	Less Valid

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5	0 – 20	Not Valid

Source: Indriani (2020)

The practicality level of the deep learning-based Student Worksheets was measured through questionnaires completed by teachers and students, then analyzed descriptively and quantitatively by calculating the percentage score using the following formula:

Practicality Percentage = (Σ Score Obtained / Σ Maximum Score) × 100%

Where:

Σ Score Obtained = Total cumulative score of respondents' answers (teachers/students)

Σ Maximum Score = Highest total score if all items receive a rating of 4

The calculated results were then interpreted according to the practicality criteria presented in Table 2.

Table 2. Practicality Interpretation Criteria for the Deep Learning-Based Student Worksheets

No	Interval (%)	Criteria
1	81 – 100	Very Practical
2	61 – 80	Practical
3	41 – 60	Sufficiently Practical
4	21 – 40	Less Practical
5	0 – 20	Not Practical

Source: Sani & Ambarwati (2024)

The effectiveness of the Student Worksheets was evaluated based on the extent to which students' critical thinking skills improved from pretest to posttest. Critical thinking scores were first converted into percentage form using the following formula:

Assessment Score = (Total Score Obtained / Maximum Score) × 100%

The resulting percentages were subsequently classified according to the critical thinking ability levels presented in Table 3.

Table 3. Classification of Critical Thinking Ability Levels

Percentage (%)	Kategori
81,25 < x ≤ 100	Very High
71,5 < x ≤ 81,25	High

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62,5 < x ≤ 71,5	Moderate
43,75 < x ≤ 62,5	Low
0 < x ≤ 43,75	Very Low

Source: Setyowati dalam Khovivah et al. (2022)

The magnitude of improvement in critical thinking skills was further analyzed using the Normalized Gain (N-Gain) formula as follows:

N-Gain (G) = (Posttest Score − Pretest Score) / (Maximum Score − Pretest Score)

Where:

Posttest Score = Student score after using the Student Worksheets
Pretest Score = Student score before using the Student Worksheets
Maximum Score = Highest achievable score

The N-Gain values obtained were then interpreted according to the effectiveness categories presented in Table 4.

Table 4. Effectiveness Categories Based on N-Gain

N-Gain Score	**Category**
G ≥ 0,70	High
0,30 ≤ G < 0,70	Moderate
0,00 < G < 0,30	Low
G = 0,00	No Improvement
−1,00 ≤ G < 0,00	Decline

Source: Sundayana dalam Khovivah et al. (2022)

DISCUSSION

This study produced a deep learning-based Student Worksheet on the Regional Development topic for Grade XII senior high school students, developed using the ADDIE model. The product was developed by integrating the deep learning approach, the Problem-Based Learning (PBL) model, QR code features, and digital flipbook technology to support learning that is more contextual, interactive, and meaningful.

Validity of the Deep Learning-Based Student Worksheets

Validation conducted by the content and media experts consistently placed the product in

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the very valid category. The results of both expert validations are presented in Table 5.

Table 5. Expert Validation Results

Validator	Percentage (%)	Category
Content Expert	97.7	Very Valid
Media Expert	96.9	Very Valid
Average	97.3	Very Valid

Source: Research data, 2025

The deep learning-based Student Worksheets developed in this study was declared very valid based on assessments from both validators. The content expert awarded a score of 97.7%, while the media expert awarded a score of 96.9%. Both results indicate that the Student Worksheets has met the eligibility criteria in terms of content, language, presentation, visual design, and its alignment with deep learning principles and Problem-Based Learning syntax.

The high validity scores reflect the fact that the Student Worksheets was purposefully designed to meet the instructional needs of Geography learning on the Regional Development topic. The content incorporated is not merely oriented toward conceptual mastery; rather, it actively guides students to analyze problems, engage in discussion, and reflect on their learning experience. The sequence of activities is systematically organized in accordance with the deep learning instructional stages and PBL syntax, ensuring a more structured and meaningful learning progression.

These findings are consistent with the theoretical framework proposed by Plomp & Nieveen (2013), who assert that the validity of an instructional product rests on two dimensions: content validity (the alignment of content with objectives) and construct validity (the coherence among components). This coherence is clearly manifested in the consistency among learning objectives, materials, activities, and assessments, all of which are oriented toward the development of critical thinking skills. This is further supported by Kosasih (2021), who states that a high-quality Student Worksheets must integrate content, structure, language, and visual presentation in a unified manner to function effectively in the learning process. Furthermore, the high validity scores are consistent with the findings of Rohmah & Murtini (2025), who reported that deep learning-based instructional media tends to receive high validity ratings due to its capacity to integrate active and contextual learning experiences.

Practicality of the Deep Learning-Based Student Worksheets

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The practicality of the deep learning-based Student Worksheets was assessed through two trial phases the limited trial and the general trial involving both teachers and students as direct users of the product.

During the limited trial conducted at SMA Negeri 1 Suwawa Timur, the teacher and student response results are presented in Table 6. The teacher response yielded an average percentage of 97.19%, categorized as very practical. The language and implementation aspects received the highest ratings, each at 100%, indicating that the instructions in the Student Worksheets were easily understood and that the activity steps could be effectively implemented in the classroom. The student response at this stage reached 86.0%, also categorized as very practical, with the activities dimension receiving the highest percentage at 87.3%.

Table 6. Student Worksheets Practicality Results from the Limited Trial

Data Source	Highest-Rated Aspect	Average Percentage	Category
Teacher Response	Language & Implementation (100%)	97.19%	Very Practical
Student Response	Activities (87.3%)	86.0%	Very Practical

Source: Research data, 2026

During the general trial conducted across four schools in Bone Bolango Regency, the consolidated practicality results are presented in Table 7. As shown in the table, practicality ratings consistently fell within the very practical category across all research sites. Teacher practicality percentages ranged from 92.5% to 98.8%, with the highest rating achieved by SMA Negeri 1 Bonepantai (98.8%) and the lowest by SMA Negeri 1 Tapa (92.5%). Student responses ranged from 86.1% to 88.7%, with SMA Negeri 1 Bulango Ulu recording the highest score (88.7%) and SMA Negeri 1 Bonepantai the lowest (86.1%).

Table 7. Consolidated Student Worksheets Practicality Results from the General Trial

School	No. of Students	Teacher Practicality (%)	Student Practicality (%)	Category
SMA Negeri 1 Tapa	26	92.5	87.7	Very Practical
SMA Negeri 1 Bulango Ulu	15	97.5	88.7	Very Practical

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SMA Negeri 1 Kabila	18	96.3	86.4	Very Practical
SMA Negeri 1 Bonepantai	22	98.8	86.1	Very Practical

Source: Research data, 2026

The high practicality scores achieved across both trial phases indicate that the deep learning-based Student Worksheets effectively supports teachers in managing the instructional process. Clear instructions, a sequential activity flow, and the integration of deep learning stages throughout each activity enabled teachers to guide the learning process in a more structured and organized manner. From the students' perspective, the positive responses reflect that the learning activities presented in the deep learning-based Student Worksheets successfully assisted them in constructing understanding in a gradual and contextual manner.

Active student engagement was further facilitated through the Problem-Based Learning syntax that served as the organizing framework for instructional activities. Group discussion processes, examination of problems, and the formulation of solutions to real-world geographical issues prompted students not merely to receive information passively, but to actively construct knowledge through direct learning experiences. This demonstrates that the developed Student Worksheets is not simply practical from a technical standpoint, but is also capable of fostering a shift in pedagogical approach from instruction previously dominated by teachers to learning that is genuinely student-centered.

These findings are consistent with the practicality criteria articulated by Danuri & Maisaroh (2019), which identify ease of use, implementation efficiency, and positive user responses as primary indicators of instructional product practicality. Khikmiyah (2021) reinforces this by asserting that a well-designed Student Worksheets is capable of enhancing learning interaction, thereby motivating students to be more actively engaged. In parallel, Aristin et al. (2023) demonstrated that problem-based approaches consistently increase student engagement and foster a more conducive learning climate. Taken together, these bodies of evidence confirm that the deep learning-based Student Worksheets developed in this study satisfies the practicality criteria and is suitable for use in senior high school Geography instruction.

Effectiveness of the Deep Learning-Based Student Worksheets

The effectiveness of the Student Worksheets was measured based on the improvement in students' critical thinking scores from pretest to posttest across both trial phases.

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Table 8. Pretest, Posttest, and N-Gain Results by School

School / Phase	No. of Students	Mean Pretest	Mean Posttest	N-Gain	Category
Limited Trial (SMAN 1 Suwawa Timur)	20	38	80	0.67	Moderate
SMA Negeri 1 Tapa	26	36	81	0.70	High
SMA Negeri 1 Bulango Ulu	15	43	80	0.65	Moderate
SMA Negeri 1 Kabila	18	40	78	0.64	Moderate
SMA Negeri 1 Bonepantai	22	36	82	0.72	High

Source: Research data, 2026

The effectiveness of the deep learning-based Student Worksheets was examined by comparing students' critical thinking scores before and after instruction across both the limited and general trial phases. All schools participating in the study demonstrated increases in mean scores following the implementation of the deep learning-based Student Worksheets.

In the limited trial at SMA Negeri 1 Suwawa Timur, students' mean score improved substantially from 38 on the pretest to 80 on the posttest, yielding an N-Gain value of 0.67, which falls within the moderate category. During the general trial, SMA Negeri 1 Bonepantai recorded the highest N-Gain of 0.72 (high category), while SMA Negeri 1 Kabila obtained the lowest N-Gain of 0.64 (moderate category). Across all five participating schools, two achieved high-category N-Gain scores and three achieved moderate-category scores, with no school falling into the low category. This demonstrates that improvements in critical thinking skills occurred consistently across all research sites. Collectively, these results confirm that the deep learning-based Student Worksheets is effective in improving the critical thinking skills of senior high school students on the Regional Development topic.

The improvement observed reflects the capacity of the deep learning-based Student Worksheets instructional activity sequence to guide students toward deeper conceptual understanding of the Regional Development material. The learning stages structured around the processes of understanding, applying, and reflecting provided students with opportunities to analyze information, connect concepts to real-world phenomena, and formulate solutions to the problems under study. This process encourages students to move beyond theoretical comprehension and to develop more critical and reflective thinking capacities. Additionally, the integration of the Problem-Based Learning model into the Student Worksheets provided a more

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active learning experience through activities involving problem identification, discussion, investigation, and solution development. These activities assisted students in developing critical thinking indicators such as analysis, evaluation, inference, and decision-making throughout the learning process.

These research findings are consistent with Brenya (2024), who explains that the deep learning approach is capable of constructing more meaningful learning experiences through students' active involvement in the instructional process. Yuan et al. (2024) similarly assert that deep learning-based instruction encourages students to build reflective and applicable understanding, resulting in more substantive knowledge acquisition. Furthermore, the results of this study reinforce the findings of Rahaningmas et al. (2025), who demonstrated that the deep learning approach is effective in improving students' critical thinking skills. From a policy perspective, the findings of this study provide empirical evidence supporting the implementation of Permendikdasmen No. 13 of 2025. The deep learning approach mandated by this regulation has been shown to be operationalizable in concrete instructional practice through appropriately designed Student Worksheets—not merely as a slogan within curriculum documents, but as an instructional practice with measurable outcomes.

CONCLUSION

This study successfully developed a deep learning-based Student Worksheet integrated with the Problem-Based Learning model to improve the critical thinking skills of senior high school students on the Regional Development topic. Based on comprehensive testing conducted across five public senior high schools in Bone Bolango Regency, three principal conclusions can be drawn.

First, the developed Student Worksheets satisfied the very valid criteria based on assessments by the content expert (97.7%) and the media expert (96.9%), demonstrating strong conceptual alignment among the deep learning approach, the PBL model, and Geography content.

Second, the Student Worksheets was demonstrated to be very practical for instructional use, with practicality percentages based on teacher responses ranging from 92.5% to 98.8% and student responses ranging from 86.0% to 88.7%. The high consistency across diverse school contexts indicates that the product possesses broad applicability.

Third, the Student Worksheets effectively improved students' critical thinking skills, as evidenced by mean N-Gain values ranging from 0.64 to 0.72 (moderate to high categories) across all participating schools. No students registered a low N-Gain score, indicating that the Student Worksheets delivered equitable benefits to students with varying initial ability levels.

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This study carries implications for both theoretical and practical dimensions simultaneously. From a theoretical standpoint, the study reinforces the perspective that integrating the deep learning approach with the PBL model in a Student Worksheet demonstrably and measurably improves critical thinking skills. From a practical standpoint, this deep learning-based Student Worksheets can serve as an innovative alternative instructional medium for senior high school Geography teachers that is relevant to both the Merdeka Curriculum and Permendikdasmen No. 13 of 2025. For future research, it is recommended that the development of deep learning-based Student Worksheets be extended to other Geography topics within Phase F, while also exploring various instructional model combinations that can be integrated with the deep learning approach.

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