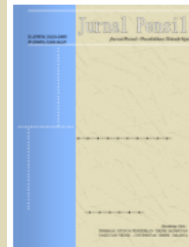


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THE EFFECTIVENESS OF THE DEEP LEARNING PEDAGOGY IN ENHANCING STUDENTS' CRITICAL THINKING ABILITIES IN LAND SURVEYING LEARNING AT VOCATIONAL HIGH SCHOOL

Sri Sumarni^{1*}, Muhammad Irsyad Akmaluddin²

^{1,2} Department of Building Engineering Education, Faculty of Teacher Training and Education, Universitas Sebelas Maret

Jl. A. Yani No.200, Kartasura, Sukoharjo, Central Java, 57161, Indonesia

*¹srisumarni@staff.uns.ac.id

Abstract

This study aimed to describe The integration of the deep learning pedagogy, analyze the significance of improving students' critical thinking skills, and determine its effectiveness in land surveying material. This research employed a quantitative method using a pre-experimental one-group pretest–posttest design. The participants were 26 students at the tenth-grade level of the Building Design and Building Information Modeling(DPIB) program at a vocational high school in Sukoharjo Regency. Data were collected through a deep learning implementation questionnaire and validated, reliable essay tests. The data were analyzed using descriptive and inferential statistical techniques., a paired sample t-test, and the normalized gain (N-Gain) test. The results showed that The integration of the deep learning pedagogy was categorized as high (mean = 3.80). Learners' critical thinking abilitiesimproved significantly (Sig. = 0.000 < 0.05), with an N-Gain score of 0.4966 (moderate category). These findings indicate that the deep learning pedagogy effectively improves learners' critical thinking abilitiesin land surveying learning.

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Introduction

Vocational High Schools play an essential role in preparing graduates who possess competencies aligned with the demands of industry and the labor market (Hazimah et al., 2025), (Pratama et al., 2018). Beyond mastering technical competencies, vocational graduates are expected to demonstrate strong critical thinking skills that enable them to understand problems, analyze information, evaluate alternative solutions, and make rational decisions in workplace situations (Asrowi et al., 2025; Suarniati et al., 2018). These competencies have become increasingly important as the construction industry grows more complex and requires workers who are adaptive, reflective, and capable of solving problems systematically (Dumitru & Halpern, 2023), (Rahmadani et al., 2023), (Rojaki et al., 2021). In addition to technical expertise, the twenty-first-century workforce also demands proficiency in critical thinking, problem solving, collaboration, and digital literacy as fundamental competencies (Esther et al., 2020). Within the construction sector, higher-order thinking skills distinguish vocational graduates and enhance their competitiveness in the labor market (Maharani et al., 2024). These demands are consistent with Indonesia's vocational education revitalization framework, which emphasizes the balanced integration of hard skills and soft skills (Ansar et al., 2025; Indartik & Husanah, 2025). Likewise, The integration of the Merdeka Curriculum through the national Deep Learning Learning Policy positions critical reasoning as one of the essential competencies developed through learning experiences that are mindful, meaningful, and joyful (Kementerian Pendidikan Dasar dan Menengah Republik Indonesia, 2025).

Despite these expectations, Indonesian learners' critical thinking abilities remain relatively low. The Programme for International Student Assessment (PISA) 2022 reported that the majority of Indonesian students were classified as low-performing students, indicating limited ability to solve problems requiring reasoning, analysis, evaluation, and problem-solving skills (OECD, 2022). Similar conditions have also been identified within vocational education. Previous studies have shown that vocational high school students generally demonstrate low levels of critical thinking, particularly in the areas of analysis, interpretation, argumentation, and inference (Kurniawan et al., 2021), (Mutakinati & Anwari, 2018), (Sutarto et al., 2020). This condition is largely attributed to instructional practices that continue to emphasize procedural mastery and practical skills, while higher-order thinking skills receive relatively limited attention (Rahmawati et al., 2020), (López et al., 2023). Consequently, students often experience difficulties in developing comprehensive conceptual understanding and solving complex technical problems, particularly when classroom instruction remains predominantly teacher-centered, thereby restricting active student engagement (Kori Sundari et al., 2024), (Nadziroh et al., 2023).

These conditions indicate that educational transformation should prioritize the development of critical thinking, problem-solving abilities, and lifelong learning competencies so that students are capable of accessing, critically evaluating, and applying knowledge in response to social changes and the evolving demands of the workplace (UNESCO, 2021).

Within the Building Design and Building Information Modeling (BIM) program, one subject that strongly requires these competencies is land surveying. Learning land surveying involves more than operating surveying instruments; students must also understand instrument functions, interpret measurement data, process survey results, evaluate measurement accuracy, and draw evidence-based conclusions. These characteristics indicate that land surveying inherently requires the critical thinking components of interpretation, analysis, evaluation, and inference, as proposed by (Facione, 1990) and (Charles D. Ghilani, 2022). Therefore, instruction in this subject should not only develop procedural skills but also foster conceptual understanding and reasoning abilities.

One instructional approach that has the potential to address these needs is the deep learning pedagogy. This approach emphasizes learning experiences that promote deep conceptual understanding through the pedagogical principles underlying mindful, meaningful, and joyful learning. Learning extends beyond procedural mastery by encouraging students to connect

concepts with authentic contexts, process information critically, engage in reflective thinking, and construct meaningful knowledge (Kementerian Pendidikan Dasar dan Menengah Republik Indonesia, 2025). Previous studies conducted by Kintoko (2025) dan Purnamasari (2026) demonstrated that implementing the deep learning pedagogy contributes to the improvement of learners' critical thinking abilities by encouraging them to analyze, interpret, and integrate concepts comprehensively. These characteristics are highly compatible with the learning objectives of land surveying, where students are expected not only to master surveying procedures but also to evaluate measurement results logically and systematically.

Although numerous studies have examined critical thinking, active learning, and the application of deep learning in teaching and learning, empirical research specifically enhancing critical thinking skills through a deep learning pedagogy within land surveying instruction in the DPIB program remains limited. This gap is noteworthy because land surveying is a technically demanding, data-driven subject requiring students to apply critical thinking throughout every stage of the surveying process, from interpreting field data to drawing technical conclusions. Consequently, further empirical findings is needed regarding the application of the deep learning pedagogy within vocational education, particularly in construction-related disciplines.

This study contributes both theoretically and practically to the advancement of vocational education. From a theoretical perspective, it enriches the existing literature concerning the effectiveness of the deep learning pedagogy in enhancing critical thinking skills within vocational education, particularly in land surveying instruction, an area that has received relatively little scholarly attention in the Building Design and Building Information Modeling (DPIB) program. Practically, this study provides empirical findings that implementing the deep learning pedagogy through the pedagogical principles underlying mindful, meaningful, and joyful learning can create more active, contextual, and reflective learning environments, thereby offering teachers an alternative Pedagogical strategy for developing learners' critical thinking abilities in vocational education.

Based on this research gap, the present study aims to analyze the effectiveness of implementing the deep learning pedagogy in enhancing students' critical thinking abilities in land surveying instruction within the Basic Building Design and Building Information Modeling (DPIB) course for students at the tenth-grade level enrolled in the DPIB program. The novelty of this study lies in integrating the pedagogical principles underlying mindful, meaningful, and joyful learning into land surveying instruction while providing empirical findings regarding their effectiveness in enhancing critical thinking skills within vocational education in the construction field.

Research Methods

This study employed a quantitative approach using a Pre-Experimental One-Group Pretest–Posttest Design. This research design was considered appropriate for measuring the direct effect of an educational intervention on a specific group when the inclusion of a control group was not feasible (Apuke, 2017). The study was conducted during the second semester of the 2025/2026 academic year at a public vocational high school in Sukoharjo Regency, Indonesia. The participants consisted of 26 students at the tenth-grade level enrolled in the Building Design and Building Information Modeling (DPIB) program, selected through a purposive sampling technique (Tongco, 2007). The research design is presented in Table 1.

Table 1. Pre-Experimental One-Group Pretest–Posttest Research Design

Group	Pre-test	Treatment	Post-test
Experimental	O ₁	X	O ₂

Description:

- O₁ = Pretest administered before The integration of the deep learning pedagogy
- O₂ = Posttest administered after The integration of the deep learning pedagogy
- X = Learning intervention using the deep learning pedagogy

The study began with the administration of a pretest to measure students' initial critical thinking skills. Subsequently, the deep learning pedagogy was implemented in land surveying instruction based on the pedagogical principles underlying mindful, meaningful, and joyful learning. At the end of the instructional intervention, students completed a posttest using the same instrument to evaluate improvements in their critical thinking skills.

The research employed two instruments: a questionnaire and an essay-based test. The questionnaire was designed to measure students' perceptions of The integration of the deep learning pedagogy using a five-point Likert scale, ranging from strongly disagree, disagree, neutral, agree, to strongly agree (Vagias, 2006). Before the data were collected, the questionnaire underwent content validity and reliability testing to ensure its appropriateness.

The essay-based test was developed to assess learners' critical thinking abilities based on the indicators proposed by (Facione, 1990), including interpretation, analysis, evaluation, and inference. The instrument was subjected to content validity testing, empirical validity testing (Headrick, 2016), reliability testing (Taber, 2018), item difficulty analysis, and item discrimination analysis, confirming that all selected items were suitable for measuring students' critical thinking skills.

Descriptive and inferential statistical techniques were employed to analyze the collected data. Descriptive statistics were employed to describe the characteristics of the research data without making generalizations (Fisher & Marshall, 2009). This analysis included the calculation of the mean, median, mode, standard deviation, minimum score, and maximum score. The descriptive analysis results were used to describe the level of implementation of the deep learning pedagogy based on the dimensions of mindful learning, meaningful learning, and joyful learning.

Furthermore, inferential statistics were employed to test the research hypothesis concerning the effect of implementing the deep learning pedagogy on learners' critical thinking abilities (Suntusia et al., 2019), (Fuad et al., 2017). Prior to hypothesis testing, the data were subjected to a normality test to ensure that the distribution met the assumptions required for parametric analysis. Hypothesis testing was conducted using a paired-samples t-test at a significance level of 5% ($\alpha = 0.05$) to determine whether a statistically significant difference existed between the pretest and posttest scores. In addition, the effectiveness of the improvement in learners' critical thinking abilities was evaluated using the Normalized Gain (N-Gain) by comparing the actual gain in students' scores with the maximum possible gain. The N-Gain values were interpreted according to the criteria proposed by (Sarifah & Nurita, 2023), which classify learning effectiveness into three categories: High ($g > 0.70$), Moderate ($0.30 \leq g \leq 0.70$), Low ($g < 0.30$) (Hake, 1998).

Research Results and Discussion

Implementation of the Deep learning pedagogy in Land Surveying Instruction

Before measuring The integration of the deep learning pedagogy through the student perception questionnaire, the instructional process was first conducted in accordance with the lesson plan that had been prepared. The integration of the deep learning pedagogy in land surveying instruction was carried out over four instructional sessions by integrating its three core principles: mindful learning, meaningful learning, and joyful learning. These principles were implemented systematically throughout each stage of the learning process, enabling students not only to develop conceptual understanding but also to actively engage in learning activities.

The principle of mindful learning was implemented by introducing the learning objectives, activating students' prior knowledge, and presenting contextual problems related to land surveying. Throughout the learning process, students were encouraged to observe the functions of surveying instruments, understand surveying procedures, analyze measurement data, and reflect on both the learning process and learning outcomes. These activities promoted students' awareness, accuracy, and responsibility throughout each stage of the instructional process.

The principle of meaningful learning was realized by connecting land surveying concepts with authentic practices in the construction industry. Students worked collaboratively in groups to conduct surveying activities, process measurement data, discuss solutions to contextual problems, and draw conclusions based on the collected data. Through these learning experiences, students gained contextual understanding that enabled them to relate theoretical concepts to their practical application in professional construction settings.

Meanwhile, the principle of joyful learning was implemented by creating an active, collaborative, and enjoyable learning environment. Students were given opportunities to participate in group discussions, present the results of their work, provide feedback on other groups' presentations, and receive constructive feedback from the teacher. These interactions encouraged active student participation throughout the learning process, creating positive learning experiences that enhanced students' motivation to engage in every stage of the instructional activities.

The integration of the deep learning pedagogy in land surveying instruction was described based on the results of a questionnaire administered to 26 students after the completion of the learning activities. The questionnaire consisted of 25 valid items covering three dimensions: mindful learning, meaningful learning, and joyful learning. The descriptive analysis results are presented in Table 2.

Table 2. Descriptive Statistics of of the Deep learning pedagogy

Aspect	Mean	Median	Mode	Standard Deviation
Mindful Learning	3,74	4	4	0,79
Meaningful Learning	3,84	4	4	0,83
Joyful Learning	3,79	4	4	0,84
Overall	3,80	4	4	0,82

As shown in Table 2, the mindful learning dimension obtained a mean score of 3.74, with both the median and mode equal to 4, and a standard deviation of 0.79. These results indicate that students demonstrated a high level of learning awareness throughout the instructional process, as reflected in their attention to learning objectives, efforts to understand the instructional materials, and accuracy during land surveying activities.

The meaningful learning dimension achieved the highest mean score (3.84), with a median and mode of 4 and a standard deviation of 0.83. This finding indicates that students perceived land surveying as highly relevant to field practice and the competencies required in the construction industry.

Meanwhile, the joyful learning dimension obtained a mean score of 3.79, with both the median and mode equal to 4 and a standard deviation of 0.84. These findings suggest that students experienced an enjoyable learning atmosphere through collaborative discussions, field practice, instructional media utilization, classroom presentations, and teacher appreciation.

Overall, the deep learning pedagogy obtained a mean score of 3.80 with a standard deviation of 0.82, indicating that students consistently perceived the learning process positively.

In addition to descriptive statistical analysis, the implementation scores were categorized using the psychological scale classification method proposed by (Azwar, 2022). This method was employed to classify the overall questionnaire scores into implementation levels. Before determining the implementation category, several statistical parameters were calculated as the basis for constructing the categorization intervals. These parameters are presented in Table 3.

Table 3. Parameters for Categorizing The integration of the Deep learning pedagogy

Parameter	Value
Number of Items	25
Minimum Score	20
Maximum Score	100
Hypothetical Mean (μ)	60
Hypothetical Standard Deviation (σ)	13,3
Number of Respondents	26
Mean Score	75,9
Category	High

To interpret the implementation scores, questionnaire results were categorized using the hypothetical mean (M_i) and hypothetical standard deviation (SD_i) following the categorization procedure proposed by (Azwar, 2022). The categorization criteria are presented in Table 4.

Table 4. Categorization Criteria for The integration of the Deep learning pedagogy

Score Interval	Category
$X > 79,95$	Very High
$60 < X \leq 79,95$	High
$40,05 < X \leq 60$	Moderate
$20,10 < X \leq 40,05$	Low
$X \leq 20,10$	Very Low

Source: Adapted from Azwar (2012)

Based on Table 3, the average implementation score was 75.9, which falls within the interval $60 < X \leq 79.95$ and is therefore classified as High. This result indicates that students responded positively to a learning process emphasizing active participation, conceptual understanding, and meaningful learning experiences.

These findings are consistent with the concept of the deep learning pedagogy introduced by the Kementerian Pendidikan Dasar dan Menengah Republik Indonesia (2025), which emphasizes three essential dimensions: mindful learning, meaningful learning, and joyful learning. In the

present study, these dimensions were implemented through activities including observations of surveying instruments, field surveying practice, survey data processing using Microsoft Excel, collaborative discussions, classroom presentations, teacher feedback, and reflective learning activities. These instructional experiences enabled students to develop a deeper understanding of land surveying concepts through authentic learning experiences.

The results further support the research conducted by Kintoko et al. (2025), which reported that implementing the deep learning pedagogy enhances instructional quality by actively engaging students in constructing knowledge, connecting concepts with real-world contexts, and reflecting on their learning experiences. Likewise, López et al. (2023) argued that technical and vocational education should adopt contextual learning environments that enable students not only to master procedural skills but also to analyze, evaluate, and make evidence-based decisions. Consistent with these findings, students in the present study did not merely learn land surveying procedures but also analyzed measurement results, interpreted field data, and drew conclusions regarding land conditions based on empirical findings.

Therefore, The integration of the deep learning pedagogy in land surveying instruction was successfully achieved at a high level. Integrating the pedagogical principles underlying mindful, meaningful, and joyful learning created a more contextual, participatory, and student-centered learning environment. These findings suggest that the deep learning pedagogy not only facilitates the achievement of learning objectives in land surveying but also establishes a strong foundation for developing students' critical thinking skills, as discussed in the subsequent research objective.

The Significance of the Improvement in Learners' critical thinking abilities After The integration of the Deep learning pedagogy

Learners' critical thinking abilities were analyzed using the pretest and posttest results to determine whether a statistically significant improvement occurred following The integration of the deep learning pedagogy. The descriptive statistics are presented in Table 5.

Table 5. Descriptive Statistics of Pretest and Posttest Scores

Statistics	Pretest	Posttest
Number of Students (N)	26	26
Minimum Score	17	25
Maximum Score	71	93
Mean	38,88	70,74

Based on Table 5, the mean posttest score was substantially higher than the mean pretest score, indicating an improvement in learners' critical thinking abilities following instruction using the deep learning pedagogy. To determine whether this improvement was statistically significant, a paired-samples t-test was conducted. The results are presented in Table 6.

Table 6. Paired-Samples t-Test Results

Variabel	t	Sig. (2-tailed)	Decision
Pretest–Posttest	-7.892	0,000	H ₀ Rejected

The paired-samples t-test revealed a significance value (Sig. = 0.000) that was lower than the significance level of 0.05, leading to the rejection of the null hypothesis and acceptance of the alternative hypothesis. These results indicate that learners' critical thinking abilities improved significantly after The integration of the deep learning pedagogy in land surveying instruction.

The observed improvement can be attributed to learning activities that actively engaged students through field observations, practical surveying exercises, survey data processing, collaborative discussions, classroom presentations, and reflective learning. These instructional activities are in line with the findings of Reynaldi (2026), who reported that Project-Based Learning promotes meaningful learning by encouraging students to construct knowledge through investigation, collaboration, and authentic project completion. Such learning experiences required students to interpret information, analyze data, evaluate measurement results, and formulate conclusions based on empirical findings, thereby fostering the development of critical thinking skills.

The present findings are also consistent with those of Nadziroh et al. (2023), who concluded that active learning effectively develops students' critical thinking abilities. Similarly, (Mailani et al., 2025) demonstrated that deep learning-based instruction enhances both conceptual understanding and critical thinking skills. Furthermore, (Freeman et al., 2014) and (Abrami et al., 2015) emphasized that active learning strategies involving problem solving, discussion, and reflection contribute significantly to the development of critical thinking. Within vocational education, these findings reinforce the conclusions of López et al. (2023) that contextual learning integrating authentic practical experiences effectively promotes students' analytical and decision-making abilities.

Accordingly, The integration of the deep learning pedagogy significantly improved learners' critical thinking abilities in land surveying instruction. These findings indicate that instructional practices integrating active, contextual, and reflective learning experiences effectively foster critical thinking among students enrolled in the Building Design and Building Information Modeling (DPIB) program.

The Effectiveness of the deep learning pedagogy in improving students' critical thinking skills

The effectiveness of the deep learning pedagogy in enhancing students' critical thinking abilities was analyzed using the Normalized Gain (N-Gain) test by comparing the pretest and posttest results. Prior to the effectiveness analysis, learners' critical thinking abilities were measured using an essay-based test instrument that had been declared valid and reliable during the instrument development stage. The instrument was developed based on (Facione, 1990) Facione's critical thinking indicators, which include interpretation, analysis, evaluation, and inference, and was contextualized within the land surveying subject matter. Therefore, the pretest and posttest data used in the N-Gain analysis represent learners' critical thinking abilities before and after The integration of the deep learning pedagogy. The results of the N-Gain analysis are presented in Table 7.

Table 7. Results of the N-Gain Analysis of Critical Thinking Skills

Indicator	Score
Mean Pretest Score	38,88
Mean Posttest Score	70,74
Mean N-Gain	0,4966
Category	Moderate

Based on Table 7, the mean N-Gain score of 0.4966 falls into the moderate category. These results indicate that The integration of the deep learning pedagogy was effective in enhancing students' critical thinking abilities in the land surveying subject, although the improvement had not yet reached the high category. These findings suggest that students demonstrated progress in interpreting land surveying data, analyzing relationships among data, evaluating the results of their work, and drawing conclusions based on the evidence obtained during the learning process.

The attainment level of the moderate category can be understood because critical thinking represents a higher-order cognitive ability that develops through a continuous learning process. (Facione, 1990) explained that critical thinking encompasses the abilities of interpretation, analysis, evaluation, and inference, all of which require consistent practice. In this study the application of the deep learning pedagogy was carried out over a period of four instructional sessions; therefore, achieving a moderate level of improvement represents a realistic outcome, particularly considering that the participants were students at the tenth-grade level who were still in the early stages of developing vocational competencies.

The findings of this study are consistent with those of López et al. (2023), who argued that the development of critical thinking skills in technical and vocational education requires contextual and interactive learning that encourages students' active participation through authentic learning experiences. In the present study, students not only performed land surveying practices but also processed and analyzed survey data, evaluated potential sources of error, and formulated technical conclusions based on the evidence obtained. These findings are in line with the characteristics of engineering and construction education, which inherently require students to develop independent learning through repeated investigative processes while critically verifying and evaluating experimental data (Lucas & Hanson, 2016) (Lucas et al., 2017). Furthermore, the findings support (Freeman et al., 2014), who reported that active learning produces better learning outcomes than lecture-based instruction. Students' engagement in observation, group discussions, field practice, data processing, presentations, and reflection provided opportunities to develop deeper conceptual understanding while simultaneously enhancing their critical thinking skills. This high level of engagement demonstrates that students were able to relate newly acquired knowledge to their existing cognitive structures, which is a fundamental principle of meaningful learning (Vallori, 2014).

Therefore, The integration of the deep learning pedagogy was proven to be effective in enhancing students' critical thinking abilities in the land surveying subject, with the improvement categorized as moderate. These findings indicate that learning activities integrating the pedagogical principles underlying mindful, meaningful, and joyful learning are capable of supporting the development of critical thinking skills in vocational education. Nevertheless, more sustained implementation is still required to achieve a higher level of improvement.

Conclusion

The integration of the deep learning pedagogy in land surveying instruction was successfully carried out and achieved a high level of implementation based on students' perceptions. The application of learning that integrates the pedagogical principles underlying mindful, meaningful, and joyful learning was able to create active, contextual, and reflective learning experiences. The implementation also resulted in a significant improvement in learners' critical thinking abilities after the learning process and was proven to be effective, with an average N-Gain score of 0.4966, which falls within the moderate category. These findings indicate that The integration of the deep learning pedagogy not only supports students' mastery of concepts in land surveying but also facilitates the development of critical thinking skills through students' engagement in observing, analyzing, evaluating, and drawing conclusions based on contextual problems.

This study contributes to the development of learning in vocational education, particularly in the Building Design and Building Information Modeling (DPIB) program, by providing

empirical findings that the deep learning pedagogy can be implemented as an pedagogical strategy to develop learners' critical thinking abilities without compromising the achievement of vocational competencies. Therefore, this approach has the potential to be applied to other vocational subjects that require higher-order thinking skills. Future studies are recommended to involve a larger number of participants, employ an experimental design with a control group, and extend the implementation period so that the effectiveness of the deep learning pedagogy on critical thinking skills and other learning outcomes can be examined more comprehensively.

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