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Development of an Integrated Inquiry Learning Model Using a Deep Learning Approach in Elementary School

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ABSTRACT

This research was motivated by the urgency of improving the quality of education and learning outcomes for elementary school students to ensure they are relevant to 21st-century competencies. The primary objective of this study was to validate the Inquiry Learning (IL) development model combined with the Deep Learning (DL) approach and to test its effectiveness on students' cognitive learning outcomes. The method used was Research and Development (R&D) with the ADDIE (Analysis, Design, Development, Implementation, Evaluation) framework, involving fifth-grade students in five elementary schools as research subjects. Data were collected through expert validation instruments, observations, and learning outcome tests (pre-test and post-test), which were then analyzed using N-Gain inferential statistics. The results showed that the IL-DL model was deemed highly valid and practical by experts and practitioners. Key findings revealed a significant improvement in cognitive learning outcomes; in a small-scale trial, the completion rate jumped dramatically from 30% in the pre-test to 95% in the post-test. This consistent effectiveness was reinforced by a large-scale trial, with a completion rate of 94.6%. Furthermore, the average N-Gain Score (g) of 0.78 (High category) and the effectiveness level of 78.54% (Effective category) confirm that the synergy between structured inquiry and in-depth learning successfully mitigates the phenomenon of shallow learning. This study concludes that the IL-DL model is a transformative solution worthy of adoption to improve the quality of learning and student competencies in elementary schools.

Keywords: Inquiry Learning, Deep Learning, Elementary School, Learning Outcomes, Students

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INTRODUCTION

According to Amalia et al. (2025), Elementary Schools (SD), as the initial foundation, must immediately shift from a merely transactional learning model to a transformational one. Essentially, basic education is the primary basis that determines the direction of character formation, while also being a crucial means of instilling knowledge and skills in students. (Jundu et al., 2020) stated that educational institutions must realize that improving quality is the only way to overcome existing backwardness. According to (Kurniawan & Aricindy, 2026), despite the high demands of the modern era, field findings indicate that elementary school learning practices are still dominated by conventional, teacher-centered methods that simply transfer information. According to Juniati & Widiana (2017), this approach significantly hinders the development of students' analytical and synthesis skills. This results in student

passivity because the learning process is dominated by the teacher. As an essential instrument, education is tasked with developing human capabilities so that everyone can adapt and maintain their existence amidst accelerating global developments. Significant changes in the current national education system are reflected in the implementation of the Independent Curriculum.

Kemendikbudristek (2022) stated that the Ministry of Education, Culture, Research, and Technology (Kemendikbudristek) launched the Independent Curriculum, which is designed to be more adaptive and efficient, with a primary emphasis on developing students' competencies and character. According to Rina & Herlambang (2025), the Indonesian government has implemented the Independent Curriculum as an educational framework that aims to provide flexibility and a conducive environment for students to optimize their full potential. Ningsih et al., (2025) revealed that the Merdeka Belajar curriculum adopts flexible and diverse intra-curricular learning. Dauly et al., (2024) stated that this approach aims to optimize student development so they can master concepts and strengthen their core competencies. According to Astuti & Aricindy (2025), the Independent Curriculum demands integration, which is realized through the subject of science. This subject is designed to equip students with a variety of competencies, including fostering curiosity, honing scientific attitudes, developing critical thinking skills, and enhancing environmental understanding related to the natural and social phenomena they encounter daily. According to Yani et al. (2024), observations showed that elementary school teachers tend to neglect the use of the surrounding environment as a learning resource or model. This practice directly limits students' holistic development and growth. According to Asih et al. (2024), several factors contribute to low student learning outcomes. Putri et al., (2022) stated that the main causes include inappropriate or unappealing learning models and media. Aricindy et al., (2023) revealed that, furthermore, teachers' tendency to rely too heavily on textbooks results in monotonous teaching activities, which in turn triggers student passivity during the learning process. To improve student learning outcomes, it is crucial for science and science learning to implement appropriate models to ensure material delivery is more understandable, engaging, and relevant (meaningful).

According to Puspita et al., (2025), as an alternative solution to this problem, Inquiry-Based Learning (IL) has long been validated as a superior method due to its ability to encourage active student participation, support the process of exploration and discovery, and stimulate scientific interest and curiosity. Wijaya (2020) stated that the Inquiry learning model is a teaching method that gives students the freedom to find the information they need for themselves, either with or without guidance from the teacher. Based on previous research conducted by Balqis et al. (2025), this study shows that applying the Inquiry Learning model, adapted to the learning styles of fifth-grade students, can improve student learning outcomes. The inquiry model is an appropriate choice for implementing learning at the elementary school level. According to Uliyandari & Lubis (2020), this is due to its ability to motivate curiosity and demand active student involvement in learning activities. Ramiyati et al., (2025) revealed

that, on the other hand, the Deep Learning approach in the context of pedagogy is defined as a systematic effort to ensure students move beyond memorizing facts (shallow learning) to building substantial understanding, connecting ideas, and the ability to transfer knowledge to other domains. Nabila et al., (2025) stated that to optimally realize the goals of the Independent Curriculum, we need a learning approach that goes beyond simply delivering material, but also fosters deep understanding, mindful learning, and emotional engagement in students. This approach is key to addressing the common problem of shallow understanding. Current research indicates that although Inquiry Learning and Deep Learning are equally important concepts, their structural and systematic integration, particularly within the context of the Indonesian elementary school curriculum, remains minimal.

The novelty of this research lies in the specific integration of two learning concepts rarely explored empirically at the elementary school level. The primary focus is on the fifth-grade Natural and Social Sciences (IPAS) subject within the Independent Curriculum framework. Balqis et al., (2025) revealed that based on research they conducted, it showed that the application of the Inquiry Learning model with adjustments to the learning styles of 5th-grade students can improve student learning outcomes. According to Dewindri et al. (2025) the research conducted shows that by integrating deep learning into the elementary school curriculum, students' curiosity can be increased. Based on previous research, the novelty of this research lies in developing an inquiry learning model integrated with a deep learning approach.

This research differs from previous studies that used only one variable (inquiry learning or deep learning). The novelty of this research lies in the development of a learning model that combines inquiry-based learning with a deep learning approach. Inquiry learning provides a procedural foundation where students are encouraged to ask questions, investigate, and build knowledge through active exploration. However, the inquiry process risks becoming merely a technical activity if not guided by a higher cognitive goal. This is where deep learning plays a compass; it requires students to move beyond memorization to conceptual understanding, knowledge transfer, and the ability to solve complex problems in real-world situations. By combining the exploratory mechanisms of inquiry with the substantive rigor of deep learning, we can create a holistic learning ecosystem. In this hybrid model, the process of asking questions is not just a starting point but a bridge to deeper thinking, enabling students to critically and creatively connect old ideas with new perspectives.

This study's significant innovation stems from the integration of two educational philosophies. Specifically, it explores the impact of combining Inquiry Learning (serving as a process model) with Deep Learning principles (focusing on outcomes such as deep conceptual mastery and the ability to connect ideas, in contrast to surface learning, which relies solely on memorization). The added value of

this development is the detailed operational description of the integration of both models into the steps of science learning, resulting in a new, validated learning syntax.

METHOD

According to Slamet, (2022), this study uses a Research and Development (R&D) design with the primary objective of creating and developing a specific Inquiry-Deep Learning Model. Research and development (R&D) in the educational context refers to a systematic method applied to create and verify the validity of products used in the learning process. Doni Hutagalung, Eko Handoyo, Argitha Aricindy, (2025) revealed that this model is designed to improve learning outcomes in Natural and Social Sciences (IPAS) for fifth-grade elementary school students, particularly in the topic of Light and Its Properties. The development process of this model, which is implemented using the ADDIE model, is directed at producing a feasible and effective product. According to Setiawan et al., (2021) the ADDIE model development process consists of five systematic phases: Analysis, Design, Development, Implementation, and Evaluation. The ADDIE model development design used in this study can be seen in Figure 1.

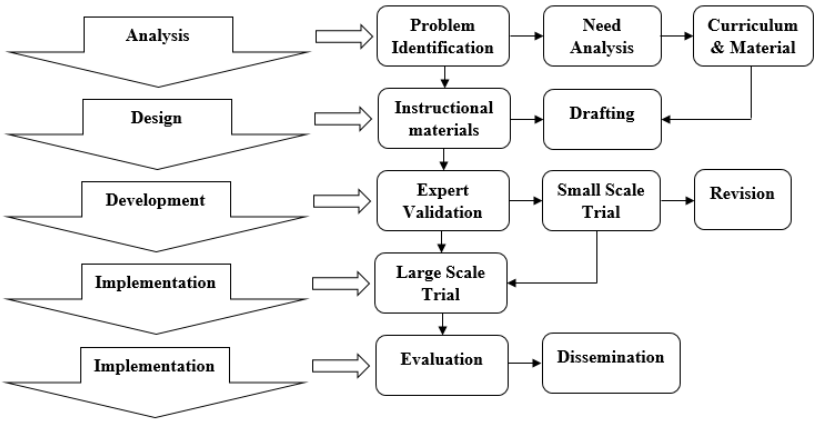

Figure 1. ADDIE Development Research Procedure Flow

According to Mulyasari et al., (2023) this learning development model adopts the ADDIE framework because its systematic stages effectively represent a structured approach to instructional development. Pranata et al., (2021) stated that the ADDIE development model was chosen because it offers a series of structured and systematic steps, ensuring that the development process runs smoothly and effectively in meeting the established needs. Aricindy et al., (2020) revealed that the implementation of this integrated model is aimed at 5th grade elementary school students' science learning with the main goal of optimizing their learning outcomes. The Analysis Phase focuses on identifying problems and product needs by conducting observations, interviews with teachers/students, and reviewing the curriculum and previous research. Ardianti et al., (2025) revealed that the results of this analysis then

become the basis for the Design Phase, where the Inquiry Learning Model integrated with the Deep Learning approach is designed, specifically for the topic "Light and Its Properties," with the main goal of improving learning outcomes. Next, according to Mustikasari, (2025) the Development Phase involves validation by a team of experts (materials, media, instruments) and product revision until it is declared valid and feasible. This feasibility is confirmed through a small-scale trial to assess the model's readability, practicality, and implementation before final revision. Once the model is deemed feasible, the Implementation Phase was carried out using a pretest-posttest design and statistical analysis (N-Gain) to measure the effectiveness of the model in improving learning outcomes, complemented by collecting teacher and student responses. Finally, the Evaluation Phase analyzes all statistical data and response results to determine success, identify the advantages and disadvantages of the Inquiry Learning Model integrated with the Deep Learning approach, before the results are published and disseminated.

Research Subjects and Instruments

Research Subjects

The subjects in this development research included fifth-grade students from five different elementary schools to ensure the validity and representativeness of the data at each stage of the ADDIE model. During the problem identification and needs analysis phase, SDN Pagu 2 was designated as the core subject of the research. Subsequently, in a small-scale trial phase, the research subjects consisted of 20 students from SDN Pagu 2. This phase focused on measuring the initial effectiveness of the Inquiry Learning Integrated Deep Learning (IL-DL) learning model and identifying aspects requiring revision before broader testing.

After product refinement, the research proceeded to a large-scale trial phase involving a wider range of subjects and diverse environments. This phase involved a total of 55 students from three different elementary schools: SDN Joho 1, SDN Joho 2, and SDN Silir. The selection of subjects spread across multiple institutions aimed to confirm the generalizability of the IL-DL model's effectiveness in consistently improving cognitive learning outcomes. All learning outcome data from the research subjects were then disseminated to the Grade 5 Teacher Working Group (KKG) in the local sub-district as a form of practical validation in the field.

Research Instrument

The main instrument used in this study was a cognitive learning outcome test, composed of a pre-test and post-test. This test instrument was designed to measure achievement of the Learning Objective Achievement Criteria (KKTP) with a minimum standard score of 75. The questions in this instrument were specifically developed to reflect the principles of Deep Learning, namely measuring reasoning ability, conceptual connections, and knowledge transfer, rather than simply superficial factual

memorization. Before use, the instrument underwent a validation process to ensure its suitability for measuring the effectiveness of the learning model intervention.

In addition to the test instrument, this study utilized the Normalized Gain (N-Gain) statistical test as an analytical tool to accurately measure the effectiveness of the intervention. The N-Gain analysis instrument uses the Meltzer formula, which compares the difference between post-test and pre-test scores with the ideal maximum score. The results of this calculation were consulted with Hake's (1999) classification criteria to determine the improvement categories (High, Medium, Low) and the effectiveness categories in percentage form. The use of this statistical instrument serves as an objective quality control to prove that the improvement in student learning outcomes is a direct impact of the implementation of the IL-DL model, so that the resulting data has high scientific credibility.

RESULTS & DISCUSSION

Result

Based on the results of the development research conducted in five elementary schools, SDN Pagu 2 was designated as the core subject for this study by identifying problems, analyzing student needs, and developing learning materials tailored to the applicable curriculum. In the initial trial, the researchers conducted a small-scale trial using 20 students from SDN Pagu 2. The results of this trial were used as the basis for revisions for the large-scale trial. The large-scale trial involved the participation of 55 students from three different elementary schools (SDN Joho 1, SDN Joho 2, and SDN Silir). The culmination of this research was the dissemination of the findings from the large-scale trial to the Grade 5 Teacher Working Group (KKG) in the relevant sub-district. The following is a presentation of the group divisions in the ADDIE development research that has been carried out in Table 1.

Table 1. ADDIE development research group division

Scale Test	Institution	Number of Students
Small Scale Test	KP2	20 Students
Large Scale Test	BJ1, BJ2, BS	55 Students

This section presents empirical findings from a field trial of the Integrated Inquiry Learning Model with Deep Learning Approach (IL-DL) in elementary schools, followed by an in-depth discussion of the benefits, pedagogical implications, and interpretation of the statistical findings. The Learning Objective Achievement Criteria (KKTP) has been set at a minimum score of 75. The research results are presented in two trial stages: a small-scale trial to compare initial effectiveness and a large-scale trial to confirm the generalization of the model's effectiveness.

Small Scale Test

This small-scale test involved 20 students from SDN Pagu 2 (KP2). The main objective of this phase was to test the differences in cognitive learning outcomes before and after using the Integrated Inquiry Learning Model Using a Deep Learning Approach.

Pretest

The following are the results of a small-scale pre-test activity that shows a general overview of student learning outcomes before the implementation of the Inquiry Learning Model integrated with the Deep Learning approach. This can be seen in Figure 2.

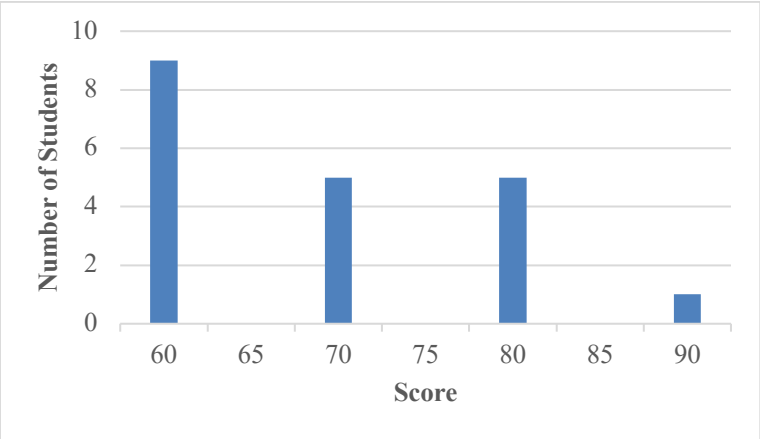

Figure 2. Learning outcomes in small-scale trials (Pretest)

Pre-test results from a small-scale trial showed that student learning outcomes were still suboptimal and did not meet targets. With a Learning Objective Achievement Criteria (KKTP) of 75, 14 students were deemed incomplete due to their low scores (60 and 70). Conversely, only 6 students successfully exceeded the threshold. This indicates that the previous learning method was ineffective for classroom implementation.

Pre-test analysis revealed that the majority of students (70%) had not mastered the material, with the lowest scores being 60 (45%) and 70 (25%). Only 30% of students successfully passed the KKTP (Qualification Competency Standard), indicating the need for transformation in learning methods. The IL-DL model offers a solution for transforming passive learning into student-oriented learning to improve analytical skills and cognitive learning outcomes. After implementing the IL-DL learning model in the classroom, a post-test was conducted.

Posttest

After conducting a small-scale pretest, it can be concluded that a learning model that can improve student learning outcomes needs to be developed. After implementing the Integrated Inquiry Learning

Model with a Deep Learning Approach (IL-DL), the following are the posttest results obtained by students, presented in Figure 3.

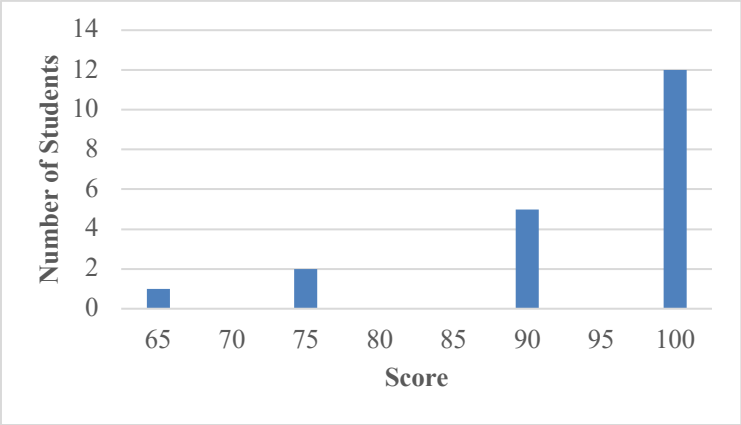

Figure 3. Learning outcomes in small-scale trials (Posttest)

The post-test assessment results provide strong empirical evidence that the implementation of the Inquiry Learning-Deep Learning (IL-DL) learning model is highly effective in optimizing students' cognitive learning outcomes in elementary schools. Referring to the Learning Objective Achievement Criteria (KKTP) set at 75, 95.0% of students successfully exceeded the passing grade with very impressive achievements. This dominant success is evident from the largest percentage of students, namely 60.0%, who were able to achieve a perfect score of 100, reflecting a deep, critical, and comprehensive mastery of the material in accordance with the principles of Deep Learning. With only a small proportion of students (5.0%) not yet achieving KKTP, this high concentration of scores in the range of 75 to 100 firmly confirms that the IL-DL model is a significant instructional solution in improving students' academic competence compared to conventional methods.

N-Gain Statistical Test (Normalized Gain)

The N-Gain (Normalized Gain) test is a crucial statistical method in research and development (R&D) of learning models. In the context of an Inquiry Learning model integrated with Deep Learning, Normalized Gain (N-Gain) analysis is applied to measure the effectiveness of interventions or treatments implemented in learning (Oktavia et al., 2019).

N-Gain provides an overview of the effectiveness of a learning model in helping students achieve the maximum possible score. N-Gain Formula Calculation according to Meltzer is done using the following formula:

$$g = \frac{Spost - Spre}{Smax - Spre}$$

Description:

g : N-Gain Score

Spost : Post-test Score

Spre : Pre-test Score

Smax : Ideal maximum score (100)

Once you have the g values, you need to categorize them based on Hake's criteria, according to Table 2.

Table 2. N-Gain score criteria category

N-Gain Value (g)	Category
$g > 0,7$	High
$0,3 \leq g \leq 0,7$	Medium
$g < 0,3$	Low

Hake, R.R. (1999)

The criteria for the effectiveness of learning outcomes based on the N-Gain value refer to the Meltzer classification, as presented in table 3 below.

Table 3. Effectiveness criteria based on N-Gain score

Percentage (%)	Interpretation
< 40	Ineffective
40 − 55	Less Effective
56 − 75	Moderately Effective
> 76	Effective

Hake, R.R. (1999)

Based on the results of data analysis using the N-Gain test processed in SPSS, a general overview of the N-Gain scores was obtained based on the learning model implementation treatment in improving student learning outcomes. A summary of the N-Gain score analysis results is presented in Table 4 below:

Table 4. N-Gain score statistical description

	Number of Students	Minimum	Maximum	Mean	Std. Deviation
NGain-Score	20	0,13	1,00	0,7854	0,29003
Valid N (listwise)	20				

The average N-Gain value of 0.7854 is in the g range > 0.7. Based on Hake's (1999) classification criteria, this gain falls into the "High" category. This indicates that the use of the IL-DL learning model can provide a very significant increase in understanding or learning outcomes for students. A maximum value of 1.00 indicates that there are students who have successfully achieved perfect improvement from their initial score.

In addition, the N-Gain test also presents N-Gain data in percentage form to measure the level of effectiveness in using the IL-DL learning model, which is presented in table 5.

Table 5. Statistical description of N-Gain effectiveness

	Number of Students	Minimum	Maximum	Mean	Std. Deviation
NGain-Effectiveness	20	12,50	100,00	78,5417	29,00251
Valid N (listwise)	20				

The effectiveness level of the IL-DL learning model was determined by referring to the N-Gain interpretation classification table presented. Based on the average percentage gain of 78.54%, the results were categorized as 'Effective' because they exceeded the minimum criteria threshold of 76%.

Large-Scale Test (Confirmation of Generalizability of Effectiveness)

After a small-scale test was conducted and data was obtained that the use of the IL-DL learning model was effective for implementation in the classroom, a large-scale test was conducted in the development model. The large-scale trial was conducted to verify the consistency of the model's effectiveness in a more diverse environment. This research involved a total of 55 students from three different elementary schools (BJ1 - SDN Joho 1, BJ2 - SDN Joho 2, and BS - SDN Silir). The following are the student learning outcomes in the large-scale test which have been presented in Figure 4.

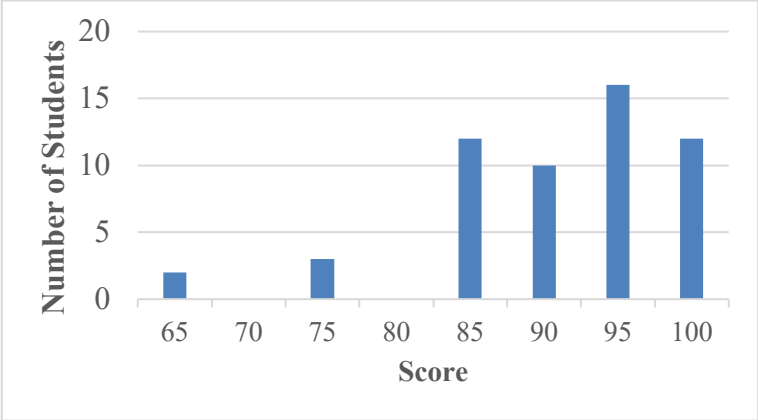

Figure 4. Learning outcomes in large-scale trials

A large-scale trial involving 55 students from SDN Joho 1, SDN Joho 2, and SDN Silir proved that the Inquiry Learning-Deep Learning (IL-DL) learning model is highly effective in significantly and evenly improving cognitive learning outcomes. Based on the Learning Objective Achievement Criteria (KKTP) 75 standard, 50 students successfully exceeded the threshold with dominant high scores in the range of 85 to 100, including 12 students who achieved a perfect score, with a pass rate reaching 94.6%. Only a few students have not reached the minimum limit, so this finding strengthens the conclusion that

the IL-DL model is a very feasible and superior alternative solution to be implemented in elementary schools to improve students' mastery of concepts.

Discussion

Key Findings of the Study The key findings of this study indicate that the development of the Inquiry Learning model integrated with the Deep Learning (IL-DL) approach has proven to be highly valid, practical, and effective in improving the cognitive learning outcomes of elementary school students. Specifically, this model succeeded in drastically increasing student learning completion from 30% in the pre-test stage to 95% in the post-test stage in a small-scale trial. This result was also consistent in a large-scale trial with a completion rate reaching 94.6%. Statistically, the average N-Gain Score of 0.78, which is included in the "High" category, and the effectiveness level of 78.54%, which is included in the "Effective" category, proves that the synergy between structured inquiry and deep learning is able to mitigate the phenomenon of shallow learning in students.

Comparison with Previous Research These findings reinforce previous research by Balqis et al., (2025) which stated that the Inquiry Learning model can improve the learning outcomes of fifth-grade students. However, this study provides novelty by combining inquiry with Deep Learning, which according to Dewindri et al., (2025) has been proven effective in increasing students' curiosity. While previous research often only uses a single variable (only inquiry or only deep learning), the integration of the IL-DL model addresses the risk of the inquiry process becoming merely a technical activity without a high cognitive goal. According Samadun et al., (2023) The Deep Learning approach in this model functions as a "compass" that ensures students move beyond memorization to conceptual understanding and knowledge transfer. In this mechanism, the DL approach serves as a rigorous quality control—a crucial role to prevent undirected exploration as can potentially occur with pure IL. According to Prihantini et al., (2025) DL ensures that each phase of student inquiry is always closely tied to essential learning objectives and the construction of meaning.

Based on research Nisa et al., (2023) in addition to focusing on cognitive outcomes, the IL-DL model is also essential for developing 21st-century skills, particularly critical thinking, and Based on research Uliyandari and Lubis, (2020) these skills are honed through the implementation of Evidence-Based Critical Thinking Exercises integrated into each syntactic step, where students are required to conduct inductive and deductive reasoning, as well as test hypotheses and draw conclusions supported by the evidence found. Based on research Safitri and Triwahyudianto, (2024); Dewindri et al., (2025) these exercises directly foster structured and analytical critical thinking skills. Other positive impacts include a significant increase in student Engagement and Learning Autonomy through an active, student-centered process At the institutional level, this model is transformative for elementary school teachers

and the education system as a whole, as it provides a reliable solution to address chronic problems such as low cognitive learning outcomes and failure to achieve the Learning Objective Completion Criteria (KKTP) in the classical curriculum. Finally, this model offers validated Structured Guidance for teachers, enabling them to implement inquiry effectively with quality assurance that results in deep understanding.

The significance of these findings lies in their potential as a transformative solution to address the chronic problem of primary education, namely the dominance of conventional, teacher-centered methods. Practically, the IL-DL model provides structured guidance for teachers to implement the Independent Curriculum more adaptively and efficiently, particularly in science and science subjects. This model encourages emotional engagement and independent learning in students, which are crucial for developing 21st-century skills such as critical thinking through evidence-based critical thinking exercises.

The limitations of this study include the fact that, despite showing very positive results, the scope of the material tested is limited. The implementation of this model was specifically focused on the topic "Light and Its Properties" in fifth grade elementary schools. Furthermore, the effectiveness of this model is highly dependent on the teacher's ability to provide structured guidance to prevent students' exploration from becoming undirected. Limited learning resources in schools can also be a barrier to facilitating Deep Learning needs that require in-depth analysis and complex problem solving.

Based on these limitations, future research is recommended to expand the application of the IL-DL model to other topics and grade levels to test its broader generalizability. It is also necessary to develop more adaptive and interactive technology-based teaching materials to support each phase of student inquiry. Furthermore, intensive training for teachers through the Teacher Working Group (KKG) forum is recommended to fully master the syntax of this model, as well as school policy support in providing adequate resources to support deep and meaningful learning.

CONCLUSION

This development research concluded that the implementation of the Inquiry Learning model integrated with the Deep Learning (IL-DL) approach significantly transformed the cognitive learning outcomes of elementary school students. This was evident in the dramatic increase in student completion rates in small-scale tests. In the pretest, only 30% of students achieved the Learning Objective Achievement Criteria (KKTP). However, after the IL-DL model intervention, this figure increased significantly to 95% in the posttest. The model's consistent effectiveness was also verified through large-scale testing in three different schools, with a completion rate of 94.6%. This confirms the model's strong generalizability across diverse school settings.

Statistically, the IL-DL model's superiority was reinforced by an average N-Gain Score of 0.7854, categorized as "High," and an effectiveness rate of 78.54%, categorized as "Effective." The synergy between the inquiry process and deep learning successfully overcomes the weakness of conventional learning models, which often only address superficial understanding (shallow learning). With rigorous quality control mechanisms, the deep learning approach ensures that each phase of student exploration remains relevant to essential learning objectives, enabling students to develop deeper understanding, reason logically, and transfer knowledge to new situations.

As a practical solution to improving the quality of education in elementary schools, it is recommended that the IL-DL model be adopted as one of the primary learning models in the curriculum at the school level. Teachers need to be facilitated with intensive training through the Teacher Working Group (KKG) forum to fully master the syntax of this model, particularly in providing structured guidance that prevents student exploration from becoming undirected. Furthermore, the development of adaptive, technology-based teaching materials is essential to support the inquiry phases, making them more interactive and engaging for students.

Furthermore, schools and education offices should provide policy support in the form of adequate learning resources to facilitate Deep Learning needs. By disseminating the results of this research to the wider educational community, it is hoped that the IL-DL model can become a new standard in creating a meaningful, in-depth, and future-oriented learning ecosystem for students.

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