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Teachers' Planning Practices for Deep Learning-Oriented Science Instruction: A Qualitative Case Study in Indonesian Junior High Schools

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ABSTRACT

Background. This study investigates the pedagogical strategies employed by junior secondary science teachers in designing deep Learning–oriented instruction on living systems and cells. Deep Learning is defined as an instructional orientation that promotes conceptual understanding, cognitive integration, and higher-order thinking skills.

Methods. Adopting a qualitative case study approach, data were collected from five science teachers across diverse school contexts in Bantul Regency. Empirical evidence was generated through five semi-structured, in-depth interviews conducted between 18-22 July 2025, each lasting 60–90 minutes, complemented by a document analysis of five instructional planning documents, one from each participating teacher. The interviews were guided by a combined curricular and professional noticing framework, enabling systematic examination of teachers' decision-making processes.

Results. The findings reveal three significant insights. First, Grade VIII science lesson planning aligned with the independent curriculum and deep learning principles is structured to support experiences of conceptual understanding, application, and reflection. Conceptual understanding is facilitated through discussions, multiple learning resources, student projects, and presentations; application is emphasized through real-world case studies; and reflection is integrated through the evaluation of learning outcomes and opportunities for personal improvement. Second, teachers anticipate variations in students' prior knowledge and tendencies toward passive participation. Third, in response, they adopt an asset-based approach and implement instructional steps to promote mindful, meaningful, reflective engagement that extends beyond traditional cognitive assessment.

Conclusion. Theoretically, this study contributes to the literature on science pedagogical design by demonstrating how professional noticing can function as an analytic lens for understanding teachers' planning for deep Learning, particularly in contexts transitioning toward competency-based curricula. The findings also extend existing discussions on deep Learning by illustrating how teachers translate curricular expectations into concrete pedagogical decisions within real classroom constraints.

1. INTRODUCTION

Science education (IPA) in schools plays a strategic role and aligns with Asta Cita's objectives, serving as a critical foundation for realizing the vision of "Together Toward Golden Indonesia 2045." This role is pivotal in equipping the nation's young generation with the competencies required to confront the challenges of the twenty-first century, characterized by complexity and rapid change (Fauziah, 2022). Effective science instruction is one of the essential pillars in developing human resources, particularly youth, in critical thinking, creativity, collaboration, and communication (the 4Cs) (Bergmann et al., 2021), thereby correlating positively with their future success (Yusmar & Fadilah, 2023). However, science learning practices in schools remain dominated by passive transmission-based approaches, which are less effective in fostering students' deep conceptual understanding. This is indicated by the significant decline in Indonesia's 2022 PISA science scores, which dropped by 13 points—surpassing the global average decline of 2 points—thus signaling weaknesses in the quality of science learning in the country(Mutawadia et al., 2023).

Deep Learning, as a transformative paradigm for improving instructional processes, emphasizes active student participation, contextual relevance, and continuous competency development. This approach has been shown to enhance conceptual understanding, foster higher-order thinking skills, and increase student motivation to learn (Hasanah et al., 2023). By tailoring instructional planning to processes, content, and learning products in accordance with students' characteristics, differentiated instruction lays the foundation for creating profound, transformative learning experiences (Hasanah et al., 2023). Differentiated Learning requires effective instructional management that considers students' readiness and involves selecting diverse strategies. Alongside growing attention to instructional quality, student well-being has also gained recognition as an integral component of the educational process(Hossain et al., 2023).

Within science learning specifically, deep learning approaches such as inquiry-based tasks are shown to strengthen students' confidence (Nugraha & Nurita, 2021; Juanta et al., 2023; Tifani & Dewi, 2023), while collaborative structures contribute to students' social and emotional development (Kusuma & Sumianto, 2022; Sabrina et al., 2024; Hasanah, 2024). These findings illustrate the global and national state of the art in designing learner-centered science instruction. However, empirical studies that develop or test comprehensive instructional management models grounded in deep learning principles remain limited in Indonesia (Siregar, 2025). This gap is particularly problematic because deep Learning requires coherent planning that aligns learning goals, sequencing, scaffolding, and assessment—not merely the adoption of isolated strategies. Deep Learning is conceptualized not merely as a curricular revision but as a transformative pedagogical framework engineered to foster meaningful and relevant learning experiences (Quinn et al., 2019). Within this context, the role of the teacher undergoes a fundamental redefinition, shifting toward that of a facilitator and instructional orchestrator who prioritizes holistic self-development and students' social contributions (Darling-Hammond et al., 2017). The primary focus of this conceptualization is to reinforce the multifaceted dimensions of graduate competencies.

However, the effective implementation of Deep Learning within science lesson planning necessitates specific professional capacities. Teacher Noticing is defined as the ability of educators to identify, interpret, and respond to critical incidents within the instructional process (Gamoran, Sherin, & Van Es, 2009). In the realm of science planning, teachers must be capable of "noticing" student readiness diagnostically before instruction commences. Identifiable findings in this stage include metacognitive gaps and varying levels of experience in both cognitive processes and practical applications (Zimmerman, 2002). Furthermore, teacher noticing enables the identification of students' self-efficacy, particularly in resilience and learner autonomy.

Pedagogical strategies in science education should be grounded in progressive principles that stimulate high-level cognitive engagement through authentic inquiry (Hmelo-Silver, 2004). Effective instructional design must integrate problem-based scenarios with continuous formative assessment to reinforce students' metacognitive awareness (Black & Wiliam, 2009). Nevertheless, educators must also recognize the complex challenges inherent in designing in-depth science instruction, such as limited laboratory resources and the risk of cognitive overload from information density.

To mitigate these obstacles, tactical instructional responses are required within the planning phase. The deployment of faded scaffolding serves as a strategic alternative to enhance student competency throughout the deep learning process. Finally, the development of authentic assessment rubrics that emphasize the quality of scientific reasoning and argumentation—rather than the mere empirical accuracy of the outcome—is crucial for supporting a comprehensive Deep Learning ecosystem (Pellegrino, 2017).

A growing consensus in international research underscores that student engagement in deep Learning is shaped by the quality of instructional planning, which enables students to construct conceptual connections and transfer knowledge across contexts (Bråten & Skeie, 2020). Deep learning implementation also involves the interplay of four components: pedagogical strategies, supportive learning environments, digital technology use, and partnership-based collaboration. However, despite this conceptual clarity, very little is known about how teachers in Indonesia—especially at the junior secondary level—design lesson plans that integrate these components for complex science topics such as living systems and cells.

Studies on deep Learning in education have emphasized the importance of fostering conceptual understanding, cognitive integration, and higher-order thinking skills (Fullan & Langworthy, 2014)(J. A. C. Hattie & Donoghue, 2016); however, most research has primarily focused on the effects of instructional strategy implementation on student learning outcomes, rather than on teachers' pedagogical decision-making processes at the lesson planning stage. Meanwhile, the literature on teacher noticing has extensively examined how teachers observe, interpret, and respond to students' thinking during classroom interactions and professional Learning. However, it remains limited in systematically connecting these processes to deep learning–oriented science lesson planning practices. Research on science lesson planning itself tends to emphasize the structural alignment of learning goals, assessment, and instructional strategies (Shulman, 1986)(Bowen, 2017; Wiggins & McTighe, 2005)(McTighe, 2010)(Council et al., 2012), without explicitly explaining how teachers' professional noticing functions as a cognitive–pedagogical mechanism that bridges curricular demands with instructional designs that support deep Learning. Consequently, an empirical and conceptual gap persists regarding how teacher noticing is operationalized in science lesson planning to enact deep Learning, particularly in contexts transitioning toward competency-based curricula.

This study contributes by articulating the operational relationships among deep Learning, teacher noticing, and science lesson planning within the context of junior secondary school teaching practice. The findings demonstrate that deep Learning is not merely positioned as an instructional goal but is translated into concrete pedagogical decisions through teachers' professional noticing processes, such as anticipating variations in students' prior knowledge, participation tendencies, and potential conceptual obstacles. Teacher noticing functions as an analytic lens, enabling teachers to integrate curricular demands, learner characteristics, and classroom constraints into instructional designs that promote conceptual understanding, contextualized application, and meaningful reflection. Accordingly, science lesson planning is conceptualized not simply as an administrative task, but as a reflective and adaptive professional practice that mediates between deep learning principles and the realities of classroom instruction(Darling-Hammond et al., 2017)(van Es & Sherin, 2021)(Jacobs et al., 2010)(Shulman, 1986)(Bowen, 2017)(McTighe, 2010)(Council et al., 2012). Theoretically, these findings extend understanding of noticing as a mediating mechanism in science pedagogical design. At the same time, in practice, they offer an analytical framework for teachers and curriculum developers to design instruction more strongly oriented toward deep Learning and the development of twenty-first-century competencies.

The Indonesian educational landscape, marked by geographical diversity, cultural heterogeneity, and varying socioeconomic conditions, further reinforces the importance of understanding planning processes for deep Learning. Bantul Regency serves as an analytically meaningful context because it encompasses both rural and urban junior secondary schools, reflects diverse learner profiles, and demonstrates a strong commitment to instructional improvement through BOS Kinerja programs. These characteristics make

Bantul a strategic site for investigating how teachers plan for deep Learning in science instruction, particularly to facilitate understanding, application, and reflection across diverse classroom conditions.

2. METHODS

This study employed a qualitative case study design to explore the processes underlying junior secondary science teachers' planning for deep Learning–oriented instruction. The primary dataset consisted of narrative accounts obtained through five in-depth, semi-structured interviews, each conducted between 18 and 22 July 2025 and lasting 60–90 minutes. The interview protocol was developed based on the theoretical framework of teachers' curricular and professional noticing (Qi et al., 2025). The study was conducted in Bantul Regency. Each interview was accompanied by the collection of one instructional planning document per teacher, resulting in five documents ranging in length from 3 to 6 pages.

Purposive sampling was used to ensure representation of diverse school contexts, including: (1) regular classes in rural areas, (2) all-girls classes, (3) all-boys classes, (4) regular classes in urban areas, and (5) small schools with fewer than ten students. These criteria were selected to capture the heterogeneity of junior secondary school environments in Bantul Regency.

Data collection combined in-depth interviews and document analysis. The interview data and planning documents were transcribed and analyzed using ATLAS.ti 9, following a three-stage coding procedure: open coding, categorical (axial) coding, and thematic aggregation. Open coding was used to identify significant meaning units related to teachers' decision-making processes. Axial coding connected these initial codes into broader conceptual categories, while thematic aggregation consolidated categories into core themes aligned with the study's analytical framework.

To ensure trustworthiness, several strategies were implemented. Credibility was strengthened through source triangulation (interviews and documents), member checking in which summaries of interpretations were shared with participants for verification, and peer debriefing with a qualitative research expert. Dependability was maintained through the creation of an audit trail, documenting analytic decisions, coding iterations, and reflective memos within ATLAS.ti. Transferability was supported through thick descriptions of school contexts, teacher characteristics, and lesson planning processes. Confirmability was ensured through systematic memoing and maintaining a clear separation between raw data and analytic interpretation.

Data were analyzed using a reflexive thematic analysis approach following Braun and Clarke's six-phase framework, involving familiarization, initial coding, theme development, theme review, definition, and reporting. The analysis process began with open coding, which involved inductively identifying and labeling meaningful units from interview transcripts and instructional planning documents in order to capture variations in ideas, pedagogical actions, and teachers' professional considerations. The subsequent stage was axial/category development, during which initial codes were grouped, compared, and linked to form conceptual categories representing patterns of relationships across phenomena. This was followed by theme generation, in which the major categories were synthesized into coherent and analytically meaningful themes that reflect teachers' sense-making processes in designing deep Learning–oriented science instruction. The entire analytic process was iterative, involving ongoing reflection, theme refinement, and contextual interpretation to ensure interpretive rigor and the credibility of the findings. Data analysis followed the interactive model of Miles, Huberman, and Saldaña (2020), operationalized into:

(1) Data condensation, conducted through iterative coding and categorization;
(2) Data display, using ATLAS.ti's network views and matrix queries to map relationships across codes and categories; and
(3) Conclusion drawing and verification, involving thematic synthesis, triangulation across sources, and member-check confirmation.

3. RESULTS AND DISCUSSION

This study reveals the experiences of junior high school teachers in Indonesia in developing plans for implementing in-depth science learning. From the participants' statements, key themes can be identified as domains of in-depth learning planning. According to the participants, four key domains, individually and collectively, are considered important representative factors with specific dimensions of the concept of planning in-depth science learning in Indonesia, including teachers' conceptualization of deep Learning, analysis of students' readiness, pedagogical strategies and design decisions, anticipated challenges, and instructional responses.

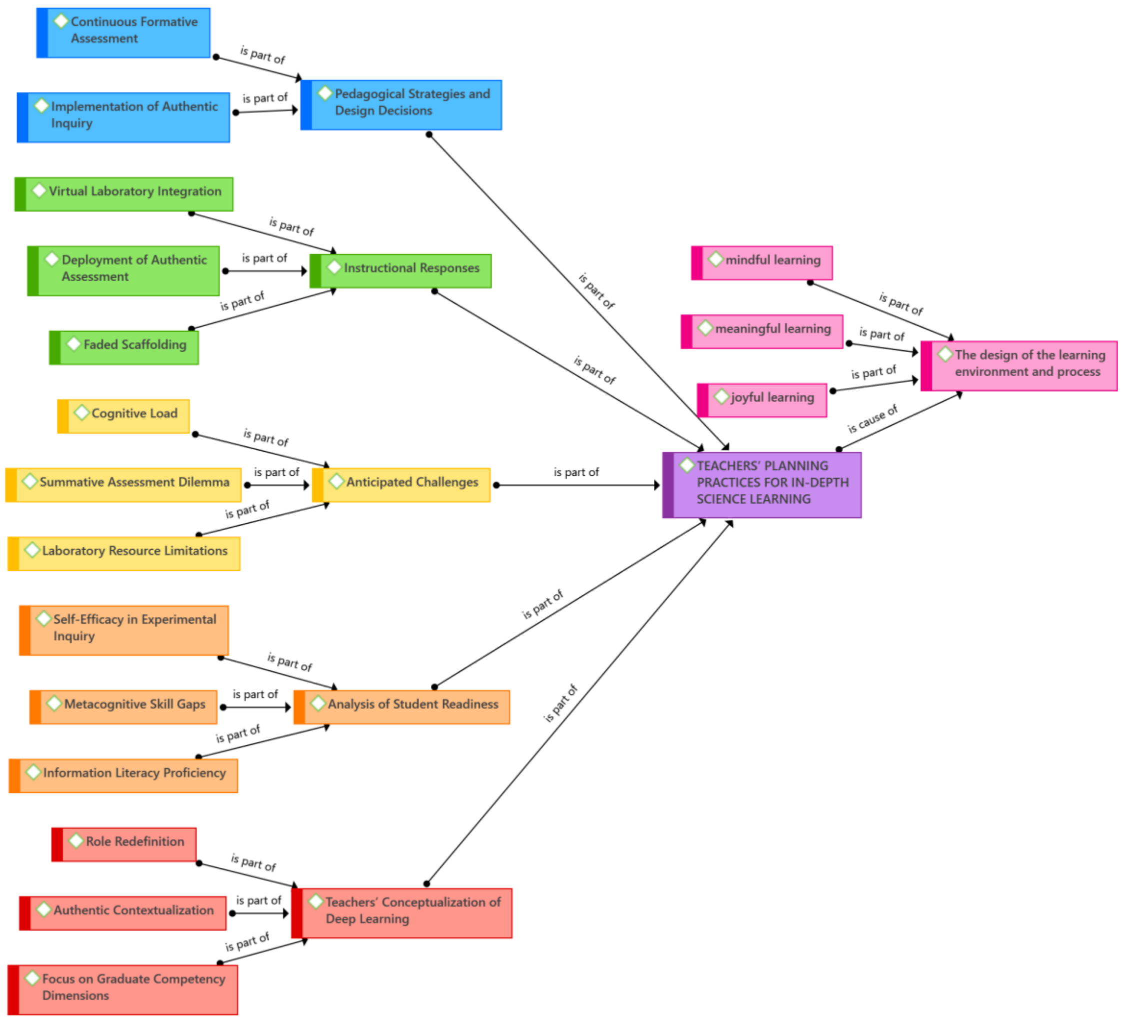

Figure 1. Conceptual model of teachers' planning practices for in-depth science learning

3.1. Results

3.1.1. Teachers' Conceptualization of Deep Learning

Teachers perceive Deep Learning not merely as a curricular revision, but as a transformative pedagogical framework designed to foster meaningful and relevant learning experiences. This approach prioritizes holistic self-development and social contribution. The findings indicate:

3.1.1.1. Role Redefinition: A shift in teacher identity from primary information providers to facilitators and instructional orchestrators. The following is the relevant statement submitted by P1:

"Students will learn the material, play interactive animation-based games, and then discuss in groups the differences between animal and plant cells."

A statement made by P5 supports P2's statement:

"As a teacher, I encourage active engagement—students do not simply receive information, but are required to seek data, conduct observations, and develop projects ."

3.1.1.2. Focus on Graduate Competency Dimensions: Conceptualizations are centered on fostering spiritual values (Faith and Piety), critical reasoning, creativity, collaboration, well-being, and communication skills. The following is the relevant statement submitted by P4:

"Students engage in critical thinking when collaborating during practical activities, and develop a deeper sense of faith and devotion to Allah SWT through the study of living organisms at the cellular level."

3.1.1.3. Authentic Contextualization: Teachers facilitate deep Learning by constructing experiences that allow students to internalize knowledge, apply it, and engage in multifaceted reflection—analyzing facts, emotional responses, and empirical findings to evaluate their own learning objectives. The following is the relevant statement submitted by P2:

"The success indicators I set are that students can distinguish the organelles in animal and plant cells along with their functions."

A statement made by P3 supports P2's statement:

"Students compare animal and plant cells and create models of their structures and differences using materials from their surrounding environment as analogies."

3.1.2. Analysis of Student Readiness

Pre-instructional diagnostics reveal heterogeneous levels of self-regulated Learning among students:

3.1.2.1. Metacognitive Skill Gaps: A significant proportion of students lack prior experience in systematic reflection regarding their own cognitive processes. The following is the relevant statement submitted by P3:

"Students' skills in applying the eight dimensions of the graduate profile remained limited, and they tended to feel tense during learning activities, with most learning still being textbook-centered."

A statement made by P2 supports P3's statement:

"I also recognized the challenge of students' passive attitudes to engage in off-topic conversations with their seatmates."

3.1.2.2. Self-Efficacy in Experimental Inquiry: While students exhibit high engagement in practical activities, there is an identified lack of resilience and independence when navigating experimental failures (trial-and-error scenarios). The following is the relevant statement submitted by P4:

"Students experienced confusion during the transition from light microscopes to digital microscopes for cell observation."

3.1.2.3. Information Literacy Proficiency: Students demonstrate high technical proficiency in accessing digital data but require significant scaffolding in the critical validation of scientific sources. The following is the relevant statement submitted by P3:

"The challenges I face include students' low learning motivation, limited collaboration, and a lack of learner autonomy."

A statement made by P5 supports P3's statement:

"The availability of teachers' competencies in managing inquiry-based learning, as well as parental and community support for science learning, are important considerations."

3.1.3. Pedagogical Strategies and Design Decisions

Instructional design decisions are grounded in progressive pedagogical principles aimed at stimulating high-level cognitive engagement:

3.1.3.1. Implementation of Authentic Inquiry: Learning modules are designed around authentic, problem-based scenarios that necessitate rigorous student-led investigations. The following is the relevant statement submitted by P1:

"I chose project-based Learning, simple laboratory activities, and case-based discussions. Case-based discussions play a role in enhancing students' critical thinking skills and increasing their awareness of relevant and current issues."

A statement made by P4 supports P1's statement:

"Through laboratory activities, students independently find answers, making this approach particularly appropriate for observing animal and plant cells."

3.1.3.2. Continuous Formative Assessment: The design incorporates iterative feedback loops and self-assessment mechanisms to reinforce students' metacognitive awareness throughout the learning trajectory. The following is the relevant statement submitted by P3:

"I ask questions about the extent of their work and conduct direct observations. The assessments I implement include assessments during the learning process and assessments at the end of the learning activities."

3.1.4. Anticipated Challenges

Several systemic and procedural constraints were identified:

3.1.4.1. Laboratory Resource Limitations: Concerns regarding the sufficiency of infrastructure and materials if students pursue diverse, autonomous investigative paths. The following is the relevant statement submitted by P4:

"The limitation in the number of digital microscopes can be managed by continuing to use light microscopes alongside them."

3.1.4.2. Cognitive Load: The potential risk of student disengagement due to excessive information density or content volume. The following is the relevant statement submitted by P3:

"The initial characteristics were identified through observation and interviews. Students' skills in applying the eight dimensions of the graduate profile remained limited, and they tended to feel tense during learning activities, with most Learning still being textbook-centered."

3.1.4.3. Summative Assessment Dilemma: A perceived misalignment between the process-oriented deep inquiry approach and the standardized constraints of final examination formats. The following is the relevant statement submitted by P4:

"I use a variety of question types for summative assessment, including multiple-choice items, complex multiple-choice items, short essays, long essays, oral assessments, and project-based assessments."

A statement made by P1 supports P4's statement:

Assessments are conducted through daily quizzes and group discussions. Assessment can also be implemented through simple projects, as outlined in the student achievement indicators."

3.1.5. Instructional Responses

To mitigate these challenges, the following instructional interventions have been formulated:

3.1.5.1. Faded Scaffolding: Providing intensive instructional guidance at the project's inception, which is progressively withdrawn as students develop increased competency in deep learning processes. The following is the relevant statement submitted by P2:

"Specific policies and procedures for this deep learning approach are outlined in detailed written guidelines on deep learning."

A statement made by P1 supports P2's statement:

"The guidelines provide direction for students to achieve a deep understanding. By providing learning objectives, procedural steps, and guiding questions, students are encouraged to engage in independent Learning."

3.1.5.2. Virtual Laboratory Integration: Utilizing digital simulations as a substitute or complement to physical laboratories to ensure equitable access to experimental inquiry, bypassing logistical hurdles. The following is the relevant statement submitted by P3:

"I optimize available resources by applying an asset-based thinking approach."

A statement made by P5 supports P3's statement:

"Utilizing free digital learning resources."

3.1.5.3. Deployment of Authentic Assessment: Developing assessment rubrics that assign significant weight to the quality of reasoning and argumentation rather than focusing solely on the empirical accuracy of the final results. The following is the relevant statement submitted by P4:

> “I evaluate the lesson by consistently conducting evaluations through formative assessment. I use a variety of question types for summative assessment, including long essays, oral assessments, and project-based assessments.”

3.2. Discussions

3.2.1. Teachers’ Conceptualization and Epistemological Shift

The findings of this study indicate that teachers perceive Deep Learning (DL) as a significant pedagogical shift toward meaningful Learning and social contribution. This conceptualization aligns with the perspective of Fullan et al. (Fullan et al., 2017), who argue that deep Learning involves the acquisition of the “6Cs” (character, citizenship, collaboration, communication, creativity, and critical thinking), enabling students to experience contributing ideas to solve real-world problems through multiple solutions grounded in complex factors. The shift in the teacher’s role from a “primary source of information” to an “instructional orchestrator” reflects what Fullan and Langworthy (Fullan & Langworthy, 2014) describe as a transition from “old pedagogies” to “new pedagogies,” in which teachers and students function as partners. Furthermore, the emphasis on graduate attributes such as critical reasoning and creativity aligns with the “Identity” domain proposed by Mehta and Fine (2019), which suggests that deep Learning occurs when students see themselves as active contributors within a discipline rather than as passive recipients of facts. Science education, when understood more deeply, is not only practically beneficial but also encompasses moral and spiritual dimensions that enrich faith and understanding of the order of the universe as the creation of the Creator, as proposed by Gina ‘Ul Amini (Amini et al., 2024).

3.2.2. Gaps in Student Readiness and Metacognitive Awareness

Although teachers demonstrate readiness to implement deep Learning, this study identifies gaps in students’ readiness for metacognitive engagement and self-efficacy in deep Learning. Reflective activities and resilience in the face of experimental failure have not been fully developed. This represents a critical barrier, given that Hattie (J. Hattie, 2008) emphasizes that metacognitive strategies have a high effect on student achievement. Without the ability to monitor their own cognitive processes, students cannot fully engage in the cycles of “Inquiry” and “Mastery” required for deep Learning (Mehta & Fine, 2019). Students’ high interest in digital tools currently explains only surface-level technological engagement. As noted by Hattie (J. Hattie, 2012), the presence of technology alone does not guarantee Learning; rather, it is the teacher's capacity to guide students through information validation that transforms data into deep knowledge.

3.2.3. Pedagogical Design and Strategic Scaffolding

To address these readiness gaps, the instructional design adopts the principles of Authentic Inquiry and Faded Scaffolding. This approach is supported by Mehta and Fine (2019), who argue that authentic problems provide a sense of "purpose" that motivates students to master complex content. The use of faded scaffolding—initial instructional support that is gradually withdrawn—aligns with the Gradual Release of Responsibility model. This approach is crucial for managing the cognitive load identified in the findings. By utilizing Virtual Laboratories, this study addresses systemic resource constraints. From a Visible Learning perspective (J. Hattie, 2008), virtual simulations provide immediate feedback cycles, allowing students to iterate their experimental designs more rapidly than in physical environments alone; however, teachers must continue to consider the development of students' self-efficacy in confronting experimental failure.

3.2.4. Assessment Dilemmas and Authentic Responses

The tension between deep inquiry and standardized summative assessment remains a significant procedural challenge, particularly in the Indonesian context—especially in the Special Region of Yogyakarta—where teachers cannot fully disengage from government-standardized science achievement tests. Fullan 2013) notes that traditional assessment systems often serve as a "ceiling" on pedagogical innovation. The response adopted in this study—implementing Authentic Assessment that prioritizes the quality of scientific argumentation over the accuracy of final results—reflects the framework of "Assessment for Deep Learning." By focusing on reasoning processes, teachers evaluate the learning processes they design as a form of professional practice, while still preparing students for standardized science achievement tests (J. Hattie, 2012). This shift ensures that assessment reflects the complexity of inquiry processes and promotes "Mastery," as described by Mehta and Fine (2019), in which students demonstrate deep understanding through the application of knowledge in new contexts.

4. CCONCLUSION

This research concludes that the successful implementation of Deep Learning (DL) in science education is contingent upon a fundamental transformation of the teacher's role, shifting from a traditional content transmitter to an instructional orchestrator. This role is essential for cultivating a positive learning environment, attaining core scientific objectives, and integrating a spiritual dimension as a substantive learning outcome. Regarding theoretical implications, these findings corroborate the frameworks proposed by Fullan and by Mehta and Fine, demonstrating that optimal science education occurs when learners transcend mere data mastery to construct a self-identity rooted in an awareness of their existence within the Creator’s design. In terms of practical implications, educators can facilitate profound learning experiences through a structured cycle of conceptual understanding, application, and multifaceted reflection. This is achieved by employing faded scaffolding strategies and leveraging virtual laboratories to provide an experimental space that fosters student self-efficacy, particularly when navigating failure. Nevertheless, this study acknowledges systemic limitations, specifically the inherent tension between the time-intensive nature of deep inquiry processes and the exigencies of standardized academic assessments. Consequently, future research should focus on developing assessment models that monitor the quality of students' scientific reasoning while operating within the prevailing landscape of standardized testing policies.

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