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ORIGINAL RESEARCH PAPER

Exploring teachers' strategies in planning in-depth learning of science in junior high school

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Abstract
This study aims to construct an effective deep science learning planning model for junior high school teachers on the topic of living systems and cells, focusing on teacher perceptions, student readiness, and the instructional challenges encountered. A descriptive qualitative method was employed, involving in-depth interviews with science teachers and a document study of instructional plans. The findings reveal that deep science learning planning model is contingent upon a fundamental transformation of the teacher's role into an instructional orchestrator who integrates spiritual dimensions as substantive learning outcomes. While students exhibited metacognitive gaps in navigating experimental inquiry, the study highlights the efficacy of faded scaffolding strategies and virtual laboratory integration in enhancing student self-efficacy amidst resource constraints. The research concludes that despite the systemic tension between time-intensive inquiry and standardized assessments, the adaptation of flexible scaffolding is crucial for bridging scientific reasoning with national testing policies. These results corroborate existing frameworks on deep learning while providing a practical model for teachers in constructing self-identity through an awareness of the Creator's design in science.

Keywords: deep learning, instructional orchestrator, living systems and cells, metacognition

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INTRODUCTION

Natural science education has a strategic role at schools and is in line with Asta Cita—the vision of Indonesian current president, serving as an important foundation in realizing the vision of the Golden Indonesia 2045. This role is key in equipping the nation's children with the competencies needed to face the challenges of the 21st century which are full of complexity and rapid change (Malik, 2018). Effective science learning is one of the milestones in developing human resources, especially the younger generation in terms of critical thinking, creativity, collaboration, and communication skills (Bergmann et al., 2021; Norrizqa, 2021), thus positively correlating to their future success (Yusmar & Fadilah, 2023). Science learning practices in schools are still dominated by passive information transmission approaches, which are less effective in fostering deep conceptual understanding in students. This condition is indicated by a significant decrease in the 2022 PISA score in the science domain by 13 points, which exceeds the global average decline of 2 points, thus becoming an indicator of the weak quality of science learning in Indonesia (Sukristin et al., 2025).

Deep learning as a transformative paradigm in improving the learning process, emphasizes the active participation of students, the relationship of the material with the real-life context, and the continuous strengthening of competencies. This approach has been shown to contribute positively to the improvement of conceptual understanding, the development of high-level thinking skills, and Increase students' learning motivation (Hasanah et al., 2022). By tailoring planning to learning processes, content, and products according to student characteristics, differentiated learning strengthens the foundation for creating immersive and transformative learning experiences (Hasanah et al., 2022; 2023), because with differentiated learning it is necessary to work on learning management that pays attention to the readiness of students and the selection of various strategies that can be carried out (Mashuri & Hasanah, 2021; Alam, 2022). Along with increasing attention to the quality of learning, students' wellbeing also emerges as an integral part of the educational process (Hossain et al., 2023).

In-depth science learning, with its emphasis on active engagement and relevance, results in a positive impact on students' intrinsic motivation and curiosity (Artati et al., 2025). Several studies have explored science learning approaches showing that inquiry-based learning can increase students' confidence (Juanta et al., 2023; Nugraha & Nurita, 2021; Tifani & Dewi, 2023). Another study found that collaborative learning contributes to the development of students' social and emotional skills (Sabrina et al., 2024; Kusuma & Sumianto, 2022; Hasanah, 2024). Studies that specifically design and test science learning management models with comprehensive integration of deep learning principles are still relatively minimal, especially in the context of education in Indonesia (Siregar, 2025). Thus, the in-depth approach is focused on students according to their uniqueness and characteristics.

Student involvement in an immersive learning experience is important to build an understanding of fundamental concepts and the interconnectedness between elements in a subject. Through this process, students transfer and apply the knowledge and skills gained into a variety of situations, both familiar and new (Bråten & Skeie, 2020). The implementation of deep learning is not limited to the cognitive aspect alone, but rather includes four main components that interact with each other to create a well-rounded learning experience for students. The four components include pedagogical strategies, supportive learning environment design, digital technology integration, and collaboration through learning partnerships.

Although the Deep Learning (DL) approach is increasingly being adopted within Indonesia's new curriculum, its specific application to topics considered complex and abstract, such as the system of biological organization and cells at the junior high school level, remains underexplored. Most previous studies have primarily focused on general student learning outcomes, with limited research examining how teachers develop comprehensive instructional plans amidst laboratory resource constraints. Additionally, students' metacognitive readiness is frequently overlooked in the design of science learning models. Consequently, this study aims to address this gap by constructing a practical and effective deep science learning planning model for junior high school teachers, bridging the gap between inquiry-based theory and real-world school constraints. In this case, Bantul Regency was chosen as the research location because it represents the characteristics of junior high schools in rural and urban areas, with diverse socioeconomic backgrounds, but has a high spirit in developing innovative and character-oriented learning. Bantul Regency has the most target schools in Yogyakarta that have achieved advanced school performance bosses to support the implementation of deep learning, which makes it contextual and relevant as a place to explore deep learning planning. In this study, we raised a question: How is a deep science learning planning model constructed for the topic of biological organization systems and cells at the junior high school level?

RESEARCH METHOD

This research uses a qualitative approach with a case study research design as a research framework ranging from data collection to data analysis. The data collection process was carried out through in-depth interviews with five junior high schools' teachers in Bantul, who were selected through purposive sampling.

Through interviews, the researcher collected information related to the lesson plan document as the main data. The selection of research subjects was carried out by purposive sampling, taking into account the criteria, namely in regular classes in rural areas, special classes for girls, special classes for boys, regular classes in urban areas and classes in small schools with students under ten so that it is relevant to the purpose of the study describing the diversity of junior high schools in Bantul.

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 consisting of 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 analysis followed the interactive model of Miles and Huberman (Saldaña, 2021), operationalized into: (1) data condensation, conducted through iterative coding, and categorization; (2) data display, using ATLAS.ti's network views to map relationships across codes and categories; and (3) conclusion drawing and verification, involving thematic synthesis, triangulation across sources, and member-check confirmation.

RESULTS AND DISCUSSION

Deep learning is not a new curriculum, but a learning approach. Strengthening teachers' competence in implementing actual, contextual deep learning, both in a monodisciplinary and interdisciplinary approach, does not depend only on integrated training, mentoring, or guidance. These efforts also need to be supported by access to rich and varied resources and examples of deep lesson plan and practices.

In-depth lesson plan

In the in-depth lesson plan prepared by five science teachers, each of them prepares activities that encourage students to utilize various learning resources and act as an activator, collaborator and build a culture to create learning strategies according to their stages (See Figure 1).

Instructional understanding of deep learning

<u>Teacher reorientation</u>. Findings indicate a shift in teacher identity from a passive content deliverer to an instructional orchestrator who facilitates students' active exploration. The following is the relevant statement submitted by P1, which is also supported by a statement made by P5.

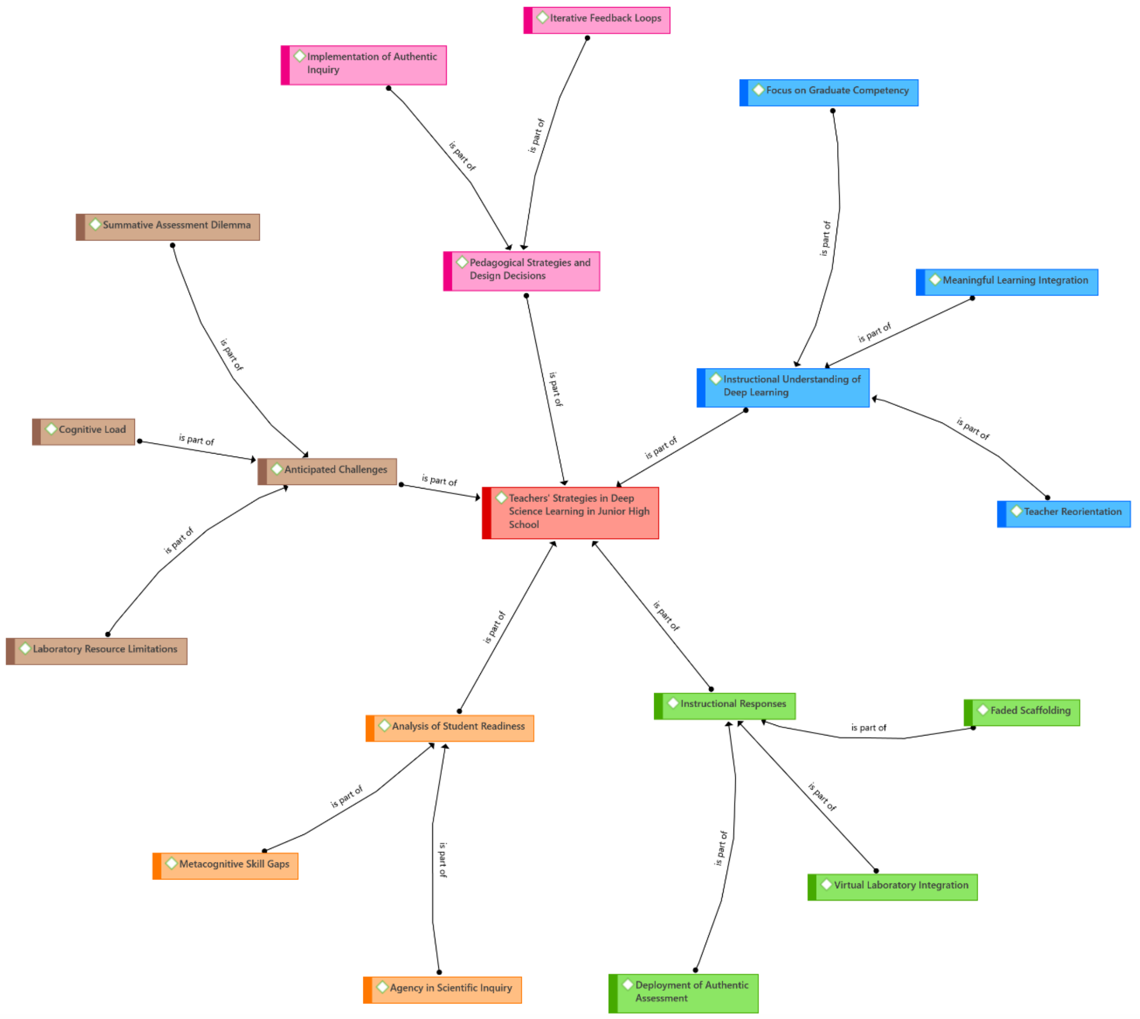

Figure 1. Conceptual model of teachers' planning practices for in-depth science learning.

P1 : "Students will learn the material, play interactive animation-based games, and then discuss in groups the differences between animal and plant cells. They will share their ideas by presenting their work, making posters, or creating simple cell models."

P5 : "As a teacher, I encourage active engagement—students do not simply receive information, but are required to seek data, conduct observations, and develop projects (such as models of levels of biological organization or reports based on microscope observations). This approach helps develop critical and analytical thinking—students are asked to connect their observations with concepts, analyze the functions of each cell part or organ, and respond to real-world problems. It also promotes collaboration and communication—students discuss their findings and present the results, learning to express ideas and receive feedback."

Focus on graduate competency. Teachers conceptualize deep learning as an instrument for building holistic character, including the integration of spiritual values and critical reasoning skills. The following is the relevant statement submitted by P4.

P4 : "Students engage in critical thinking when analyzing observations, collaborate 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."

Meaningful learning integration. The teachers' approach focuses on creating relevant learning experiences where students are encouraged to reflect on and apply cell concepts in real-world contexts. The following is the relevant statement submitted by P2 and is supported by P3's statement.

P2 : "The success indicators I set are that students are able to distinguish the organelles in animal and plant cells along with their functions. Prior to instruction, I will form discussion groups based on students' ability levels to make it easier for me to provide guidance. I will then assign additional, higher-level tasks to groups that have already demonstrated understanding, so they can continue to gain new insights and knowledge. The learning process is conducted over 8 class periods (4 meetings) and is divided into four stages: introduction of the material, discussion, presentation, and reflection and evaluation. The core learning activities take place from the first to the third meetings, with the expectation that students will develop a deep understanding of the material through textbooks, the internet, and videos, have ample opportunities for group discussions, and produce their best work to be presented."

P3 : "Students compare animal and plant cells and create models of their structures and differences using materials from their surrounding environment as analogies, drawing on literature study and their understanding of cell organelle functions."

Analysis of student readiness

Metacognitive skill gaps. Observations reveal that most students are not yet accustomed to performing self-evaluation of their own thinking processes during the learning journey. The following is the relevant statement submitted by P3, and is supported by P2 statement.

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."

P2 : "I reviewed students' final grades from the previous semester, administered a brief diagnostic assessment at the beginning of instruction, and consulted the homeroom teacher who had previously taught them. I considered students' enthusiasm or willingness to learn, their ability to grasp the learning content, and their social interactions with peers. I also recognized the challenge of students' passive attitudes during discussions and their tendency to engage in off-topic conversations with their seatmates."

Agency in scientific inquiry. Despite their enthusiasm for practical work, students demonstrate hesitation and a lack of resilience when facing technical obstacles or failures in experimental procedures. The following is the relevant statement submitted by P4.

P4 : "Students experienced confusion during the transition from light microscopes to digital microscopes for cell observation."

Pedagogical strategies and design decisions

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

Implementation of authentic inquiry. Instructional design decisions are directed toward the use of projects and laboratory activities to transform abstract cell concepts into tangible experiences. The following is the relevant statement submitted by P1, and is supported by P4's statement.

P1 : "I chose project-based learning, simple laboratory activities, and case-based discussions. Project-based learning helps students independently explore and filter information from various sources. Students are guided through a structured framework and guiding questions that encourage critical, analytical, and solution-oriented thinking. Simple laboratory activities demonstrate to students that what they learn is not merely theoretical but also tangible, thereby strengthening their conceptual understanding. Case-based discussions play a role in enhancing students' critical thinking skills and increasing their awareness of relevant and current issues."

P4 : "Through laboratory activities, students independently find answers, making this approach particularly appropriate for observing animal and plant cells. Hands-on observation experiences contribute to the development of critical thinking."

Iterative feedback loops. Teachers integrate continuous feedback loops to monitor student autonomy and ensure a deep understanding of concepts is achieved. The following is the relevant statement submitted by P3.

P3 : "To monitor students' progress, I ask questions about the extent of their work and conduct direct observations. The assessments I implement include assessment during the learning process and assessment at the end of the learning activities. Deep learning is evaluated by reviewing whether the learning objectives have been successfully achieved. I reflect on the evaluation results by revisiting the learning process and objectives, as well as examining the assessment of learning outcomes. The assessment practices are aligned with deep learning, aiming to achieve deeper and more meaningful understanding of concepts or content, rather than mere memorization of facts."

Things that teachers anticipate during the deep learning process

The things that teachers anticipate during the in-depth learning process of science in the classroom include the passive attitude of students when discussing and engrossed in telling their own stories with their classmates, low interest in learning students, lack of collaboration and independence in student learning, and diverse levels of student understanding.

Anticipated challenges

Laboratory resource limitations. Concerns emerged regarding the adequacy of infrastructure and laboratory equipment if students pursue diverse independent explorations simultaneously. The following is the relevant statement submitted by P4.

P4 : "The limitation in the number of digital microscopes can be managed by continuing to use light microscopes alongside them."

Cognitive load. There is a potential risk of decreased student engagement due to content density or excessive information volume within a limited timeframe. The following is the relevant statement submitted by P3.

P4 : "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."

Summative assessment dilemma. A perceived misalignment exists between the time-consuming deep inquiry process and standardized examination formats that tend to constrain pedagogical innovation. The following is the relevant statement submitted by P4, and is supported by P1's statement.

P4 : "I evaluate the success of deep learning on the system of biological organization and cells by consistently conducting evaluations through formative assessment. 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."

P1 : "Assessments are conducted through daily evaluations in the form of quizzes and group discussions. Assessment can also be implemented through simple projects, as outlined in the student achievement indicators. When students are able to explain the concept of the system of biological organization, actively participate during learning activities, and complete tasks and projects effectively, deep learning can be considered successful. Furthermore, when students are able to relate the concepts to real-life contexts, deep learning is truly achieved. Assessment is designed by analyzing life systems; therefore, it focuses not only on memorization but also on thinking processes, analysis, and problem-solving skills, including through the creation of cell models."

Instructional responses

Faded scaffolding. Teachers provide intensive instructional guidance at the beginning of the project, which is then gradually reduced as students' independence in the learning process increases. The following is the relevant statement submitted by P2, and is supported by P1's statement.

P2 : "Specific policies and procedures for this deep learning approach are outlined in detailed written guidelines on deep learning. I communicate performance expectations to students by clearly explaining the learning objectives, the direction of the learning activities to be implemented, including the criteria for learning mastery for this topic, and the expected outcomes after completing the learning process."

P1 : "The guidelines provide direction for students to achieve deep understanding. By providing learning objectives, procedural steps, and guiding questions, students are encouraged to engage in independent learning based on the given instructions."

Virtual laboratory integration. Digital simulations are utilized as an alternative solution to ensure equitable access to experimental investigations without being hindered by logistical constraints. The following is the relevant statement submitted by P3, and is supported by P5's statement.

P3 : "I optimize available resources by applying an asset-based thinking approach."

P5 : "Utilizing free digital learning resources."

Deployment of authentic assessment. Teachers developed assessment rubrics that emphasize the quality of scientific reasoning and argumentation rather than solely focusing on the accuracy of the final experimental results. The following is the relevant statement submitted by P4.

P4 : "I evaluate the success of deep learning on the system of biological organization and cells by consistently conducting evaluations through formative assessment. 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."

Discussion

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 Michael Fullan (Thiers, 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 (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).

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 (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 (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.

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 (Mehta & 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 offers a response to systemic resource constraints. From a Visible Learning perspective (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.

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 and Langworthy (2014) notes that traditional assessment systems often function as a "ceiling" for 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 (Hattie, 2008). This shift ensures that assessment reflects the complexity of inquiry processes and promotes "Mastery," as described by Mehta and Fine (Mehta & Fine, 2019), wherein students demonstrate deep understanding through the application of knowledge in new contexts.

CONCLUSION

This research concludes that the successful implementation of Deep Learning (DL) in science education hinges on a fundamental transformation of the teacher's role, shifting from a traditional content transmitter to an instructional orchestrator. This role is essential for fostering a positive learning environment, attaining core scientific objectives, and integrating a spiritual dimension as a substantive learning outcome. Theoretically, these findings validate the frameworks of Fullan, 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. Practically, educators can facilitate deep learning experiences through structured cycles of conceptual understanding and multifaceted reflection, supported by faded scaffolding strategies and virtual laboratories to enhance student self-efficacy. Nevertheless, the study acknowledges a systemic tension between time-intensive inquiry processes and the exigencies of standardized assessments. Consequently, future research should prioritize the development of assessment models capable of monitoring the quality of scientific reasoning while operating within the prevailing landscape of standardized testing policies.

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DECLARATION

Author contribution

All authors contribute in the research and/or writing the paper, and approved the final manuscript.

Kawit Sayoto	Conceptualizing the research idea, leading the investigation, and setting up the methodology.
Enung Hasanah	Assisting the investigation, reviewing the validity of the methodology, analyzing the data, and writing the original draft.
Muhammad Zuhaery	Assisting the investigation, reviewing the paper, and enriching the data analysis.
Russasmita Sri Padmi	Assisting the investigation, reviewing the paper, and enriching the data analysis.

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Conflict of interest

All authors declare that they have no competing interests.

Ethics declaration

We as authors acknowledge that this work has been written based on ethical research that conforms with the regulations of our institutions and that we have obtained the permission from the relevant institutes when collecting data. We support the International Journal on Education Insight (IJEI) in maintaining the high standards of personal conduct, practicing honesty in all our professional practices and endeavors.

The use of artificial intelligence
We do not use any generative AI tools to write any part of this paper.

Additional information
Not available.

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