

Descriptive Patterns of Instruction, Technology Use, and Creative Thinking in Secondary Physics Education

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Abstract: Persistent challenges in secondary physics education include uneven instructional implementation, limited pedagogical use of digital technology, and modest development of higher-order competencies such as creative thinking. While prior studies have often examined these dimensions separately, integrated descriptive evidence across authentic school contexts remains limited, particularly in resource-diverse educational environments. This study aims to descriptively analyze the alignment among instructional practices, technology-supported learning facilities, students' affective characteristics, and creative thinking-oriented physics achievement across three public senior high schools in Indonesia. A quantitative descriptive design was employed involving 102 students. Data were collected using Likert-scale questionnaires on learning implementation and affective characteristics, a binary instrument on access to digital learning facilities, and a multiple-choice physics achievement test targeting higher-order conceptual understanding in heat and thermal expansion. Descriptive statistical analysis revealed relatively consistent instructional structures across schools, yet substantial variation in practicum activities, technology utilization, and facility access. Although students demonstrated moderate motivation and positive attitudes toward physics, creative thinking achievement remained below half of the maximum score in all schools, indicating a misalignment between instructional conditions and higher-order learning outcomes. These findings provide baseline empirical evidence highlighting the need for stronger alignment among pedagogy, technological integration, and targeted competencies to support meaningful physics learning in resource-varying secondary education contexts.

Keywords: Secondary physics education, instructional alignment, digital technology use, affective characteristics, creative thinking.

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1. Introduction

Physics education plays a pivotal role in fostering students' scientific literacy, problem-solving competence, and higher-order thinking skills required for participation in contemporary technology-driven societies (Asrizal et al., 2023; Fadillah et al., 2024; Mafarja et al., 2025; Pinar et al., 2025). Nevertheless, large-scale international assessments and classroom-based investigations continue to report persistent challenges in secondary-level physics learning, including limited conceptual understanding, low engagement, and uneven achievement across school contexts (Fadillah et al., 2026). These challenges are not solely attributable to the abstract and mathematical nature of physics concepts but are also closely related to variations in instructional implementation, the availability of learning resources, and students' affective dispositions toward science learning (Fadillah & Usmeldi, 2025; Putra et al., 2024; Ugwuanyi et al., 2023; Verawati & Nisrina, 2025). Consequently, improving physics education requires a systemic perspective that simultaneously considers pedagogical practice, technological infrastructure, and learner characteristics.

Recent educational reforms have emphasized student-centered instructional models, inquiry-oriented practicum activities, and the integration of digital learning media to enhance conceptual understanding and engagement in physics classrooms (Hillmayr et al., 2020; Tanjung et al., 2025). Digital technologies, including simulations, interactive visualizations, and online learning environments, offer powerful affordances for representing abstract physical phenomena and supporting active knowledge construction (Festiyed et al., 2024, 2026; Usmeldi et al., 2026). However, accumulating evidence indicates that the presence of technology alone does not ensure meaningful learning improvement, as its effectiveness is highly contingent upon contextual conditions such as infrastructure readiness, institutional policy, teacher practice, and students' access to and use of digital devices (OECD, 2023; Siregar et al., 2026; Timotheou et al., 2023). These contextual disparities can produce substantial differences in how physics learning is experienced across schools, even within formally similar curricular systems.

In parallel, students' affective characteristics, particularly motivation, interest, and attitudes toward physics, have been consistently identified as central determinants of engagement, persistence, and academic achievement in science education (Ince, 2023; Nasir et al., 2023). Contemporary perspectives further highlight the importance of developing higher-order competencies such as creative thinking as integral outcomes of twenty-first-century physics learning (Desnita et al., 2022; Khalil et al., 2023; Tugirin et al., 2025). Despite this recognition, empirical studies frequently investigate instructional practices, technological resources, affective factors, or learning outcomes in isolation. Integrated descriptive evidence capturing how these dimensions coexist within authentic secondary school environments, particularly in resource-diverse educational contexts, remains comparatively limited. The absence of such baseline evidence constrains efforts to design context-responsive instructional innovations and informed educational policies.

Accordingly, this study aims to provide a comprehensive descriptive examination of physics learning across three public senior high schools in Indonesia by

simultaneously analyzing instructional implementation, the availability of supporting electronic learning facilities, students' affective characteristics, and cognitive learning outcomes. By documenting these interrelated empirical patterns within real classroom contexts, the study contributes foundational evidence for understanding current conditions of secondary physics education and offers an empirical basis for future instructional development, technology integration, and policy planning in resource-varying educational settings.

Theoretical and Empirical Background

Physics education plays a central role in fostering scientific literacy, higher-order thinking, and problem-solving skills required in contemporary societies. However, persistent challenges remain in secondary physics classrooms, particularly related to student engagement, instructional relevance, and the pedagogical integration of technology. Recent literature consistently highlights that the abstract nature of physics concepts, the dominance of traditional lecture-oriented instruction, and limited connections to real-world contexts contribute to students' declining interest and superficial conceptual understanding (Verawati & Nisrina, 2025). These challenges suggest that improving physics education requires not only curriculum reform but also careful alignment between instructional practices, technology use, and the development of cognitive and affective learner characteristics.

Technology Integration as Pedagogical Mediation

Digital technologies have become an increasingly prominent feature of physics education, offering tools such as simulations, virtual laboratories, augmented reality, learning management systems, and AI-based applications. Meta-analytic and review studies suggest that digital tools generally have a positive effect on student learning outcomes, particularly when used to complement rather than replace instructional practices (Hillmayr et al., 2020; Timotheou et al., 2023). Technology-supported environments can enhance visualization, experimentation, and student engagement, especially in abstract physics topics.

However, the effectiveness of technology integration is highly context-dependent. Studies on blended learning platforms, augmented reality media, and ICT-based activities demonstrate that technological tools are most beneficial when aligned with clear instructional goals and supported by teacher competence and pedagogical design (Isma et al., 2024; Tanjung et al., 2025; Zuniari et al., 2022). Without such alignment, technology risks becoming a superficial add-on that does not meaningfully contribute to learning processes. Research on AI tools such as ChatGPT further reinforces this concern, showing that while AI can support inquiry and higher-order thinking, unbalanced or unreflective use may lead to dependency rather than deep learning (Fadillah et al., 2024; Fadillah & Usmeldi, 2025).

Affective Characteristics in Science Learning

Affective factors, including motivation, attitude, self-efficacy, and emotional engagement, play a critical role in shaping students' learning experiences and outcomes in science. Empirical studies consistently report that students' motivation

and attitudes toward science are directly associated with academic achievement and learning persistence (Ince, 2023; Nasir et al., 2023). Self-efficacy, in particular, has been identified as a key mediator between instructional experiences and students' willingness to engage in challenging learning tasks.

Theoretical perspectives on self-regulated learning emphasize that affective and metacognitive processes interact dynamically during learning rather than functioning independently. The Metacognitive and Affective Model of Self-Regulated Learning (MASRL) highlights how learners' subjective experiences, such as interest, confidence, and emotional responses, shape monitoring and control processes at the task level (Efklides & Schwartz, 2024). In technology-enhanced environments, affective design features and teacher support further influence students' emotional regulation and learning effectiveness (Derakhshan et al., 2025; Wang et al., 2025). These findings suggest that affective characteristics should be considered integral components of instructional design rather than secondary outcomes.

Creative Thinking as a Higher-Order Learning Outcome

Creative thinking is increasingly recognized as a core competency in science education, closely linked to problem-solving, innovation, and cognitive flexibility. Meta-analyses and systematic reviews demonstrate that instructional approaches grounded in inquiry, STEM contexts, collaborative learning, and project-based activities have substantial positive effects on students' creative thinking (Khalil et al., 2023; Pinar et al., 2025; Ramdani et al., 2022). Creative thinking has also been shown to correlate positively with cognitive learning outcomes and learning motivation, indicating its role as both a process and an outcome of effective instruction (Adawiyah et al., 2023; Shi et al., 2023).

Despite this growing evidence, creative thinking does not emerge automatically from the presence of technology or innovative curricula. Studies on contextual teaching, digital media, and 21st-century skills curricula emphasize that creativity development requires intentional instructional scaffolding, meaningful tasks, and supportive learning environments (Desnita et al., 2022; Dilekçi & Karatay, 2023; Rosen et al., 2023). When these conditions are absent, gains in creative thinking may remain limited, even in technologically rich classrooms.

Alignment and Misalignment in Physics Learning Contexts

The literature indicates that effective physics learning depends on the alignment between instructional practices, technology integration, affective support, and higher-order learning goals such as creative thinking (Hillmayr et al., 2020). Although each of these dimensions has been examined extensively in isolation, empirical evidence suggests that misalignment among them remains common in classroom practice. Inquiry-oriented instruction may be implemented without adequate technological support, technology may be used without clear pedagogical intention, and affective dimensions may be overlooked despite their critical role in shaping learning engagement and creative outcomes.

This theoretical and empirical background underscores the need for integrated descriptive analyses that examine how these dimensions co-exist within authentic

school contexts. Examining patterns of alignment and misalignment is essential for informing evidence-based instructional improvement and for identifying leverage points to enhance the quality of secondary physics education.

Operational Definition of Alignment and Misalignment

In this study, alignment does not refer to a statistical congruence index but to the descriptive consistency among instructional practices, technology utilization, affective engagement, and higher-order learning outcomes observed within the same educational context. Misalignment is therefore operationalized as a patterned discrepancy in which relatively favorable instructional or affective conditions coexist with comparatively limited creative thinking outcomes. The construct is interpreted descriptively by comparing tendencies across measured dimensions rather than by inferential or correlational modeling. This operationalization is consistent with descriptive educational system analysis aiming to identify contextual gaps prior to explanatory investigation.

2. Method

Research Design

This study employed a quantitative descriptive research design to systematically describe the characteristics of physics learning practices, the use of electronic learning media, students' affective dispositions, and learning outcomes across different school contexts (Creswell & Creswell, 2017). Rather than examining causal relationships, the study aimed to capture empirical patterns of instructional implementation and student engagement as they naturally occur in classroom settings, which is consistent with descriptive approaches commonly used in educational research (Fadillah et al., 2025).

Participants and Context

The participants were 102 senior high school students drawn from three public high schools in Bengkulu Province, Indonesia. The schools shared comparable curricular structures but differed in terms of learning facilities and technological infrastructure. School A consisted of 35 students, School B involved 34 students, and School C included 33 students. The gender distribution across schools is summarized in Table 1. All participants were enrolled in physics courses during the data collection period, and data were gathered during regular instructional activities with institutional permission.

Table 1. Participant distribution across schools

School	Total Students	Male	Female
School A	35	9	26

School B	34	14	20
School C	33	5	28
Total	102	28	74

Instruments

Data were collected using a set of structured instruments designed to capture instructional, infrastructural, affective, and cognitive dimensions of physics learning. The primary instrument was a five-point Likert-scale questionnaire measuring the implementation of physics learning. This questionnaire examined three interrelated dimensions: instructional practices associated with the learning model, the implementation of experimental or practicum activities, and the utilization of electronic learning media and digital teaching materials. Likert-scale measurement enabled students’ perceptions and classroom experiences to be assessed systematically and comparably across school contexts (DeVellis & Thorpe, 2021).

To contextualize instructional conditions, a binary-response questionnaire was administered to assess students’ access to and use of digital learning facilities. The instrument captured information regarding device ownership, permission to bring devices to school, internet availability, and the use of digital technology specifically for physics learning.

Students’ affective characteristics were measured using a Likert-scale questionnaire encompassing three constructs: learning motivation, learning interest, and attitudes toward physics. These constructs represent core dimensions of student engagement that have been consistently associated with participation and persistence in science learning (Kwarikunda et al., 2021).

Students’ cognitive outcomes were assessed using a contextual conceptual reasoning test consisting of multiple-choice items. The items were designed to require idea generation, interpretation of physical situations, and selection of non-routine solutions rather than recall of memorized facts. Therefore, the instrument does not measure divergent creativity (e.g., fluency or originality production), but rather creative conceptual performance in physics problem solving, representing the application of knowledge in unfamiliar contexts. Each item required students to interpret physical situations, apply conceptual reasoning, and select solutions in non-routine contexts rather than recall isolated facts. Correct answers were scored as one point and incorrect answers as zero, producing a total score that reflects students’ creative conceptual performance in physics. The percentage scores reported in the Results section therefore represent the proportion of correct responses as an indicator of creative thinking-oriented physics achievement.

Prior to administration, the instruments underwent content validation by physics education experts to ensure alignment with the targeted constructs and curriculum scope. These procedures ensured that the instruments provided valid and reliable measurements for descriptive analysis across school contexts. An overview of the instruments and measured constructs is presented in Table 2.

Table 2. Overview of research instruments

Instrument	Construct Measured	Scale	Number of Items
Learning implementation questionnaire	Learning model, practicum activities, electronic media use	Likert (1–5)	21
Supporting facilities questionnaire	Access to and use of digital learning facilities	Binary (0–1)	7
Affective questionnaire	Motivation, interest, attitude toward physics	Likert (1–5)	53
Physics creative thinking achievement test	Creative conceptual performance in heat and thermal expansion	Dichotomous (0–1)	10

Instrument Development and Pilot Testing

To ensure measurement quality, all instruments underwent expert validation and pilot testing prior to the main data collection. Content validity was first evaluated by physics education experts to confirm alignment with the intended constructs and curriculum scope. Minor wording refinements were made based on expert feedback.

A pilot study was then conducted to evaluate clarity, readability, and internal consistency reliability. The learning implementation and supporting facilities questionnaire (28 items) was piloted with 35 students and demonstrated good reliability (Cronbach's $\alpha = 0.868$). The affective questionnaire (53 items) was piloted with 33 students and showed excellent reliability (Cronbach's $\alpha = 0.947$). Students participating in the pilot study were not included in the main sample.

Following minor adjustments, the instruments were administered in the main study. Reliability remained stable, with Cronbach's $\alpha = 0.855$ for the learning implementation and facilities questionnaire (N = 102) and Cronbach's $\alpha = 0.942$ for the affective questionnaire (N = 102). All values exceeded the recommended threshold of 0.70, indicating satisfactory internal consistency for descriptive research purposes.

Data Analysis

Data analysis was conducted using descriptive statistical techniques. Mean scores were calculated to summarize the level of instructional implementation, utilization of electronic learning media, and students' affective characteristics. Percentages were used to describe the availability of supporting facilities and indicators of creative thinking across schools. The use of descriptive statistics allowed patterns and tendencies in the data to be interpreted clearly without inferring causal relationships (Field, 2024).

3. Results and Discussion

Implementation of Physics Learning

The implementation of physics learning was examined in terms of the learning model, practicum activities, and the use of electronic media. The mean scores for each aspect across the three schools are presented in Figure 1. The results show that the implementation of the learning model obtained mean scores above 3.60 in all schools, with School C reporting the highest mean score (3.70), followed by School B (3.65) and School A (3.62).

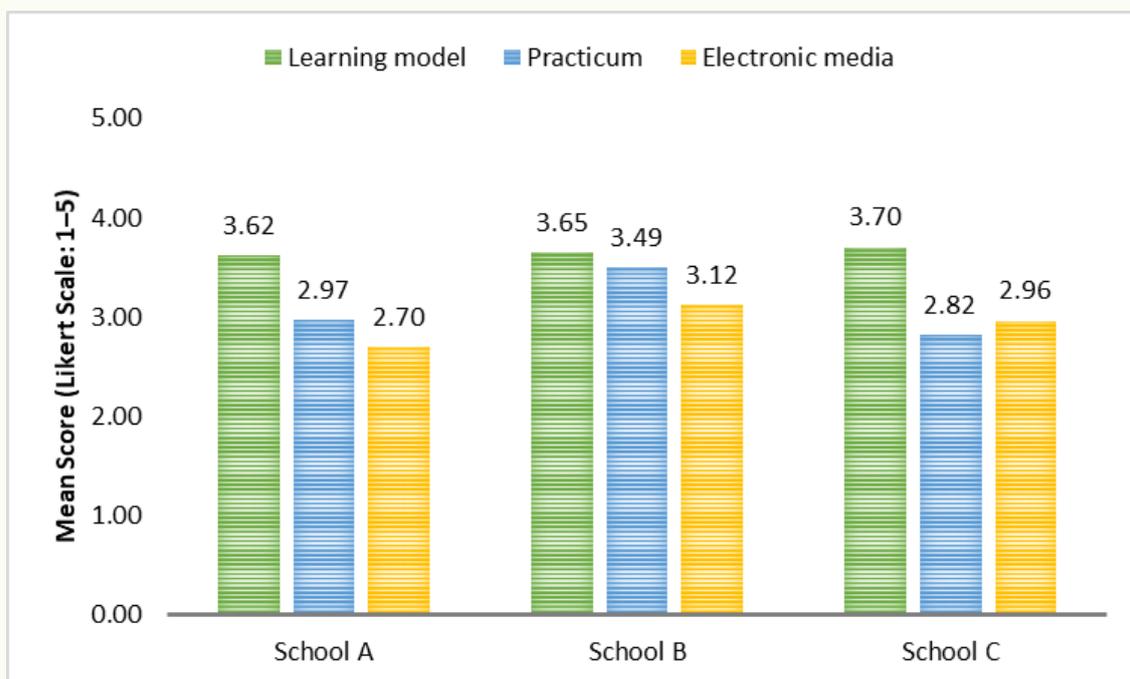


Figure 1. Mean scores of physics learning implementation (learning model, practicum activities, and electronic media use) across schools

Practicum activities showed more variation across schools, as illustrated in Figure 1. School B reported the highest mean score (3.49), while School A and School C reported lower mean scores of 2.97 and 2.82, respectively. Similarly, differences were observed in the use of electronic media, with School B obtaining a higher mean score (3.12) compared to School C (2.96) and School A (2.70).

The availability of supporting facilities for electronic learning is summarized in Figure 2. Smartphone ownership was high across all schools, reaching 97.14% in School A and 100% in both School B and School C. In contrast, laptop or PC ownership varied substantially across schools. Permission to bring digital devices to school was limited in all schools, with values below 20%. Internet availability and projector availability were generally high, although the use of digital devices specifically for physics learning differed across schools.

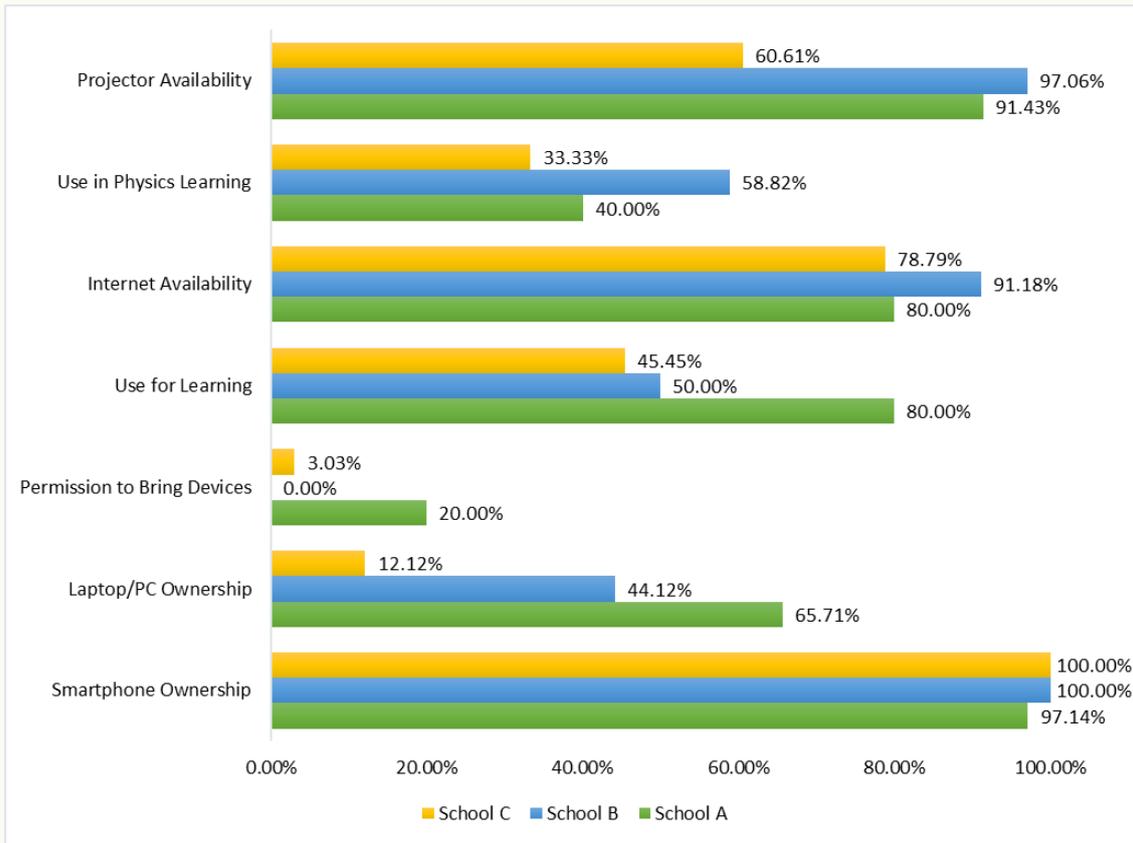


Figure 2. Percentage of supporting facilities for electronic learning across schools

Students' Affective Characteristics

Students' affective characteristics were examined in terms of learning motivation, learning interest, and attitudes toward physics learning. The mean scores for each affective dimension across the three schools are presented in Figure 3.

The results show that learning motivation obtained mean scores ranging from 3.62 to 3.99, with School B reporting the highest score. Learning interest showed mean scores between 2.99 and 3.21, while learning attitudes ranged from 3.69 to 4.08 across schools. These results indicate differences in affective profiles among students in the three schools.

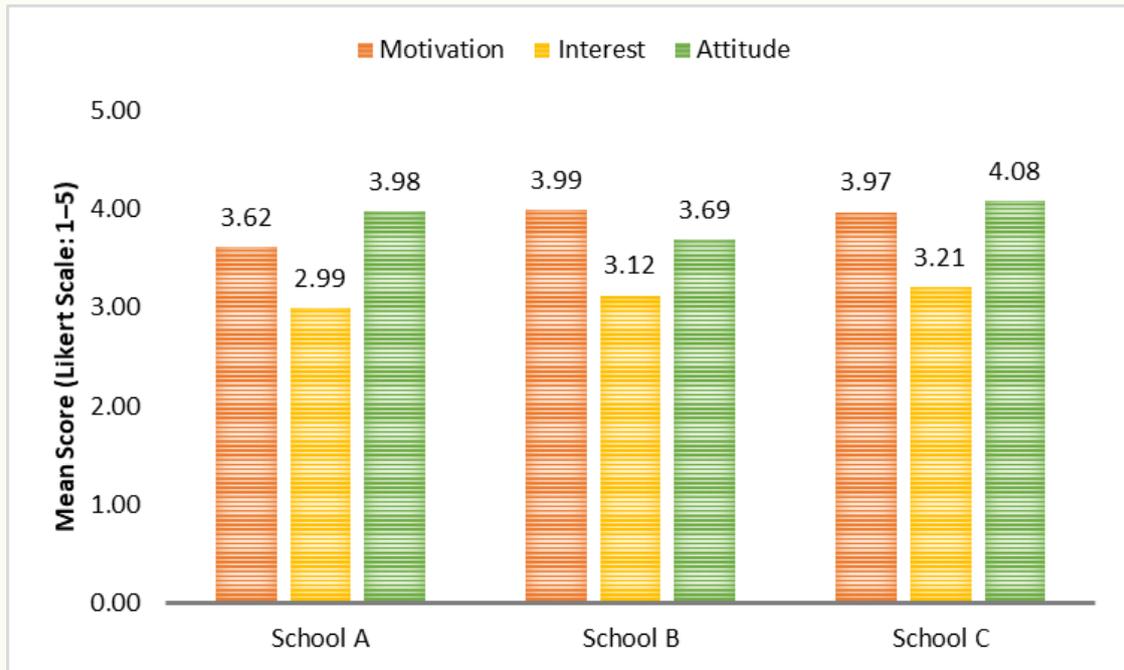


Figure 3. Mean scores of students' motivation, interest, and attitudes toward physics learning across schools

Cognitive Learning Outcomes

Students' creative conceptual performance was examined using percentage scores, as presented in Figure 4. The results show that School A reported a creative thinking percentage of 41.14%, followed by School C at 36.11% and School B at 33.94%. These percentages describe variations in students' creative thinking levels across the three schools.

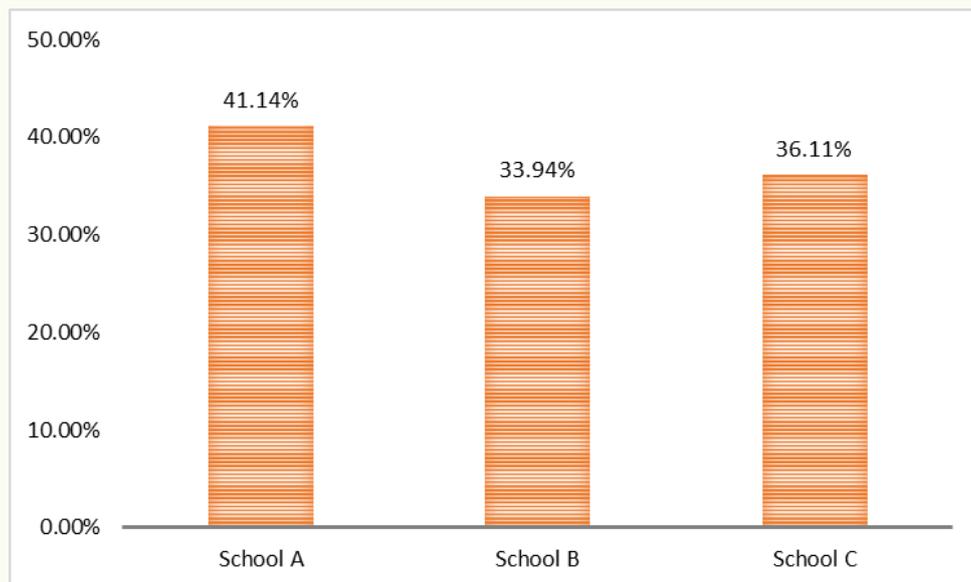


Figure 4. Percentage of students' creative conceptual performance across schools

Before interpreting the findings, it is important to clarify the meaning of creative thinking used in this study. The term creative thinking here refers to creative conceptual reasoning in physics contexts rather than divergent idea production typically measured using open-ended creativity tests. The instrument was designed to capture students' ability to interpret unfamiliar physical situations and select non-routine solutions, representing applied conceptual flexibility within disciplinary knowledge.

Patterns and Variations in Physics Instruction Across School Contexts

The findings reveal a clear pattern of instructional consistency accompanied by meaningful variations across school contexts, with the implementation of the physics learning model appearing relatively uniform across the three schools, as reflected by mean scores exceeding 3.60 in all cases. This consistency suggests that core instructional structures, such as lesson sequencing, teacher explanation, and task organization, are largely standardized across schools operating under the same national curriculum framework. Such uniformity is commonly observed in physics classrooms where curriculum alignment and examination-oriented practices guide instructional routines, often resulting in similar pedagogical patterns across schools (Verawati & Nisrina, 2025). However, the descriptive evidence also reveals that consistency at the structural level does not necessarily translate into uniformity in experiential learning opportunities.

Practicum activities exhibited greater variation across schools, with School B reporting notably higher mean scores than Schools A and C. This pattern indicates that hands-on experimentation remains unevenly implemented, despite its recognized role in supporting conceptual understanding and inquiry-oriented learning in physics. Prior studies emphasize that instructional models grounded in inquiry and conceptual change, such as the 5E model, are particularly effective when practical experimentation is systematically embedded in classroom practice (Ugwuanyi et al., 2023). Differences in practicum implementation may reflect disparities in laboratory access, time allocation, or teacher readiness to facilitate inquiry-based activities.

Similarly, the use of electronic learning media varied across schools, suggesting that digital integration in physics instruction remains context-dependent rather than systemic. This finding resonates with evidence showing that the pedagogical impact of digital tools in science education is strongly mediated by institutional capacity, teacher training, and alignment with instructional goals rather than mere availability of technology (Hillmayr et al., 2020; Timotheou et al., 2023).

These instructional differences become more interpretable when examined alongside facility-related conditions. Although smartphone ownership was nearly universal, access to laptops or personal computers and permission to use digital devices in school were limited. This mismatch reflects a broader challenge in technology-enhanced physics learning, where high levels of device ownership coexist with restricted pedagogical utilization due to institutional norms and uneven digital readiness (Tanjung et al., 2025; Timotheou et al., 2023). Figure 5 visually maps instructional implementation (learning model, practicum activities, electronic media

use) against key facility indicators (device ownership, permission to use devices, and internet/projector availability) across schools, illustrating how institutional practices mediate the translation of available resources into meaningful learning experiences.

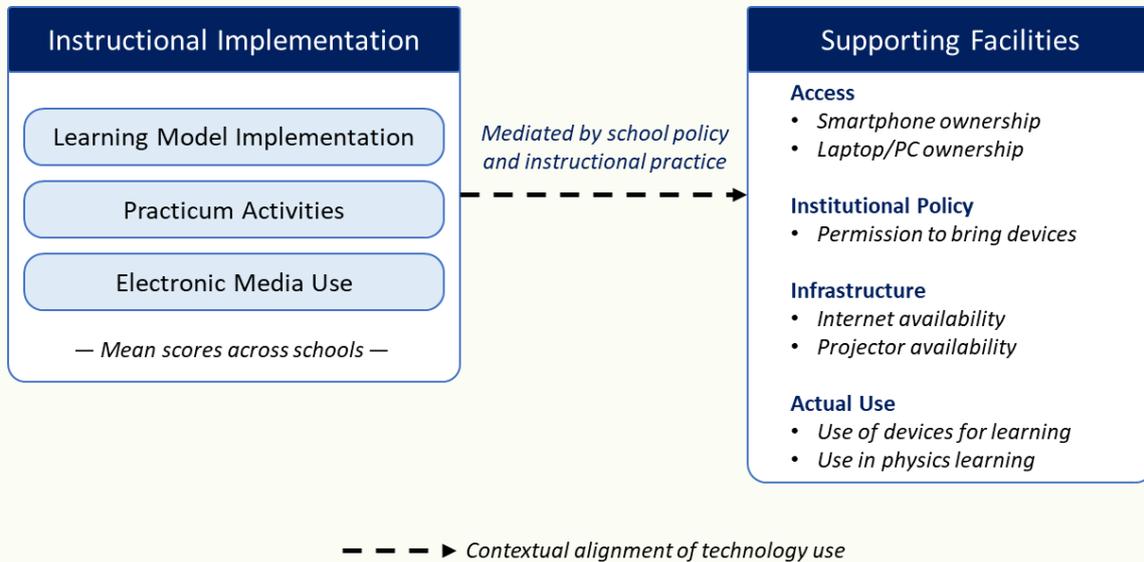


Figure 5. Alignment between instructional implementation and supporting facilities in physics learning across schools

Interpreting Students' Affective Profiles in Contextualized Physics Learning

An interpretation of students' affective profiles indicates moderate to high levels of motivation and attitudes toward physics learning, while learning interest remains comparatively lower across the three schools. This pattern suggests that students generally recognize the importance of physics and demonstrate persistence in learning activities, yet do not consistently experience strong engagement or enjoyment during instruction. Such a distinction aligns with contemporary perspectives emphasizing that motivation and attitude do not automatically translate into sustained interest without engaging learning experiences (Ince, 2023; Nasir et al., 2023).

Variations in affective scores across schools further indicate that affective dispositions are shaped by localized instructional experiences rather than curriculum content alone. Schools reporting higher levels of practicum implementation and electronic media use also tended to show stronger motivational profiles. While causal relationships cannot be inferred within a descriptive design, this pattern is consistent with research showing that interactive, technology-supported, and inquiry-oriented learning environments are associated with more positive motivational and affective outcomes in science learning (Fadillah et al., 2024; Verawati & Nisrina, 2025).

Moreover, recent work on inquiry learning climates highlights the importance of social and communicative dimensions, such as teacher support and shared interpretation, in shaping students' affective engagement in physics classrooms (Fadillah et al., 2026). Taken together, the findings suggest that affective

characteristics function as a sensitive indicator of how instructional practices are experienced by students, reflecting not only what is taught but how learning environments are socially and pedagogically enacted.

Instructional Conditions and the Limited Development of Creative Thinking

When examined in relation to instructional conditions, students' creative conceptual performance remained modest across all schools, with percentages below 50%, despite relatively positive instructional implementation and affective profiles. This finding indicates a gap between routine conceptual learning and the flexible application of knowledge in unfamiliar contexts. In physics education, such performance typically develops through sustained engagement in inquiry-oriented and non-routine problem-solving activities rather than through structured explanation alone (Akam et al., 2019; Khalil et al., 2023; Pinar et al., 2025).

The descriptive alignment between moderate practicum implementation, limited technology-mediated exploration, and modest creative thinking outcomes suggests that creative competence is unlikely to develop without intentional instructional emphasis. Meta-analytic evidence shows that approaches such as problem-based learning, project-based learning, and STEM-integrated instruction yield substantially stronger effects on scientific creativity than conventional instructional approaches (Akam et al., 2024; Pinar et al., 2025; Ramdani et al., 2022).

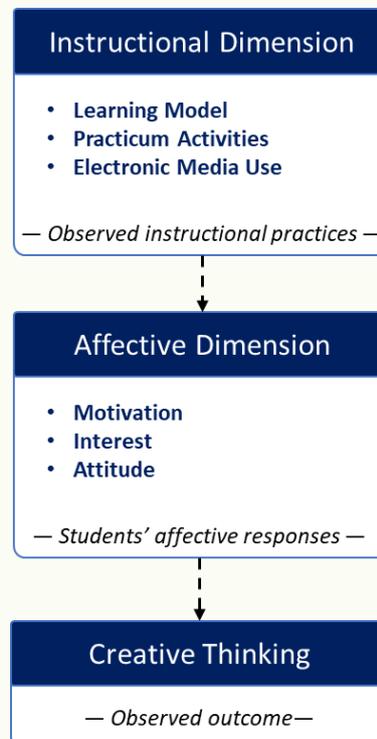
Figure 6 presents a descriptive framework linking instructional implementation (learning model, practicum, electronic media use), students' affective characteristics (motivation, interest, attitude), and creative thinking outcomes. Rather than implying causality, the framework illustrates the coexistence and interdependence among these dimensions, reinforcing the view that creative thinking develops within an instructional–affective ecosystem shaped by pedagogy, learning resources, and classroom culture (Adawiyah et al., 2023; Putra et al., 2024; Shi et al., 2023).

Integrated Interpretation of Instruction–Affect–Outcome Alignment

Taken together, the findings portray physics learning as a system in which instructional structure, learning resources, and student dispositions are closely intertwined, yet not always coherently aligned in supporting higher-order learning outcomes. While classroom instruction followed relatively consistent pedagogical routines across schools, the enactment of practicum activities and pedagogical uses of digital media varied considerably. These variations coincided with differences in facility access, digital readiness, and institutional norms, echoing broader evidence that successful technology integration in science education depends on systemic alignment rather than isolated innovations (Timotheou et al., 2023; Verawati & Nisrina, 2025).

At the student level, moderately positive motivation and attitudes indicate a general willingness to engage with physics learning, even when learning interest and creative thinking outcomes remain constrained. This pattern suggests that students may comply with instructional demands without fully experiencing the exploratory, generative, and problem-oriented dimensions of physics learning. Rather than reflecting limitations in student capability, the findings point to instructional

environments that prioritize structured knowledge transmission over inquiry, creativity, and higher-order thinking. Viewed descriptively, this study highlights how stable instructional routines can coexist with limited opportunities for creative and inquiry-based learning, particularly in contexts where experiential and technology-supported practices are unevenly implemented.



Arrows indicate descriptive relationships, not causal effects.

Figure 6. Descriptive framework linking instructional practices, students' affective characteristics, and creative thinking in physics learning

Policy Implications and Practical Recommendations

The descriptive patterns identified in this study provide several implications for educational policy and classroom practice. First, the findings indicate that instructional structures across schools are relatively standardized, yet opportunities for experimentation and technology-supported exploration remain uneven. This suggests that improving physics learning quality requires policies that move beyond curriculum standardization toward supporting instructional enactment. Educational authorities should therefore prioritize structured support for practicum implementation, including time allocation, laboratory accessibility, and teacher professional development focused on inquiry-oriented experimentation rather than solely content coverage.

Second, the widespread ownership of smartphones contrasted with restricted classroom use highlights an institutional–pedagogical gap. Rather than prohibiting devices, schools may adopt regulated academic-use policies that allow smartphones to function as learning tools for simulations, data collection, and collaborative

problem solving. Clear classroom management guidelines and teacher training in pedagogical digital integration are essential to ensure that technology supports conceptual reasoning rather than distraction.

Third, the coexistence of positive motivation with limited creative thinking outcomes indicates that affective readiness alone does not produce higher-order competencies. Classroom practices should therefore incorporate non-routine problem-solving tasks, contextual physics scenarios, and structured inquiry cycles that require students to interpret unfamiliar situations. Teachers can operationalize this through problem-based learning, guided inquiry worksheets, and conceptual discussion sessions that explicitly target reasoning flexibility.

Finally, at the system level, the results suggest that improving higher-order learning outcomes requires alignment among curriculum goals, instructional practices, and available resources. Policy initiatives should therefore focus on integrated implementation frameworks that combine instructional guidance, technological facilitation, and assessment approaches emphasizing conceptual reasoning rather than procedural recall.

Limitations

This study has several limitations that should be considered when interpreting the findings. First, the research employed a descriptive cross-sectional design; therefore, the results represent contextual patterns rather than causal relationships among instructional practices, affective characteristics, and creative thinking outcomes. Future studies using longitudinal or experimental approaches are needed to examine directional effects.

Second, the sample involved students from three public senior high schools within a single provincial context. Although the schools differed in infrastructure conditions, the findings may not represent all educational settings, particularly private schools or regions with substantially different socio-economic and technological characteristics.

Third, the study relied primarily on self-reported questionnaire data for instructional implementation and affective characteristics. Such measures may be influenced by students' perceptions and response tendencies. Observational data or teacher-reported measures could strengthen future investigations.

Fourth, the creative thinking measure assessed creative conceptual reasoning in physics through structured contextual multiple-choice items rather than open-ended production tasks. Consequently, the findings should be interpreted as indicators of applied conceptual flexibility within disciplinary problem solving, not general divergent creativity.

Despite these limitations, the study provides a useful baseline description of how instructional, infrastructural, affective, and cognitive dimensions coexist in authentic classroom environments.

4. Conclusion

This study provides a descriptive account of physics learning across three public senior high schools by examining instructional implementation, supporting learning

facilities, students' affective characteristics, and cognitive learning outcomes within authentic classroom contexts. The findings indicate that physics instruction is generally implemented in a structured and relatively consistent manner, whereas practicum activities and the pedagogical use of electronic learning media vary considerably across schools; moreover, despite widespread access to smartphones and basic technological infrastructure, institutional regulations and classroom practices appear to constrain the meaningful instructional integration of digital resources. At the student level, motivation and attitudes toward physics were moderately high, yet learning interest and creative thinking outcomes remained comparatively modest, suggesting that positive affective dispositions alone are insufficient to support higher-order competencies when instructional environments provide limited opportunities for inquiry, experimentation, and creative engagement. Because the study employed descriptive analysis, the findings should be interpreted as contextual patterns rather than causal relationships. Collectively, the study contributes descriptive empirical evidence clarifying how instructional, infrastructural, affective, and cognitive dimensions coexist, and at times misalign, within secondary physics learning systems in resource-diverse educational contexts, while also highlighting the need to align instructional design, practicum opportunities, and technology use with higher-order competency development and establishing a contextual baseline for future explanatory, intervention-based, and longitudinal research in developing educational systems.

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