Evaluating the Need for Creativity and Metacognition in STEM Integration for Sustainable Education within the Pancasila Student Profile Strengthening Project

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Abstract

This study explores the integration of metacognitive strategies, STEM elements, creativity, and Assessment as Learning (AaL) within the Pancasila Student Profile Project (P5) teaching materials in Indonesia's Kurikulum Merdeka. Utilizing a qualitative design, the research involved rubric-based analysis of 32 P5 modules and semi-structured interviews with 10 teachers from urban and rural schools. Findings revealed that while the modules address themes of sustainability, they remain narrowly focused and exhibit moderate integration of ESD (1.3), creativity (0.5), STEM (1.6), and metacognitive scaffolding (1.3). The materials often lacked open-ended problem-solving, project-based design, and reflective prompts essential for fostering creativity and self-regulated learning. Triangulated data showed consistency between module analysis and teacher perspectives, highlighting gaps in problem-action alignment and superficial STEM applications. Thematic analysis also identified limited teacher familiarity with AaL and STEM-PjBL, reinforcing the need for targeted professional development. The study concludes that strengthening teacher capacity, scaffolding inquiry-based strategies, and revising assessment frameworks are critical to enhancing the transformational potential of P5 for 21st-century learning.

1. INTRODUCTION

In recent years, there has been a growing emphasis on embedding creativity as a core objective in school curricula. Creativity is not merely an artistic trait, but a multidimensional cognitive capacity closely linked to innovation, problem-solving, and critical thinking (Mamoura & Raftopoulou, 2020). As global challenges become increasingly complex, creativity is widely recognized as a key competency for helping students navigate uncertain futures, contribute to social progress, and engage in sustainable development (Aquije-Mansilla et al., 2025; Mróz & Ocetkiewicz, 2021). Within the framework of Education for Sustainable Development (ESD), fostering creativity is essential to equip learners with the ability to identify, analyze, and respond to sustainability issues in innovative and socially responsible ways (Indriyana & Susilowati, 2020; Sobari et al., 2022).

One promising pathway to nurturing creativity in ESD is through the integration of STEM education, which promotes a holistic and interdisciplinary approach to learning (Bojulaia & Pleasants, 2021; David & Jairo, 2021; Filipe et al., 2024). STEM-based pedagogy not only deepens students' conceptual understanding but also supports creative thinking through real-world applications (Hebebci & Usta, 2022; Sumarni & Kadarwati, 2020). Research has shown that embedding creative practices into STEM education enhances student motivation, engagement, and critical thinking. In parallel, metacognition defined as the ability to reflect on and regulate one's own thinking—has emerged as a crucial driver of creativity (Stanton et al., 2021; Xiaoyu et al., 2019). When students engage in metacognitive strategies, they become more aware of their creative thought processes, enabling them to make deliberate choices when approaching complex problems (Gamby & Bauer, 2022; Vettori et al., 2018).

Despite the pedagogical potential of STEM and metacognitive instruction, their effectiveness hinges on the adoption of appropriate assessment paradigms. Assessment as Learning (AaL) addresses this need by positioning students as active participants in the assessment process. Unlike the more commonly applied Assessment for Learning (AfL), which focuses on teacher feedback, and Assessment of Learning (AoL), which is summative and product-focused, AaL emphasizes self-regulation, reflection, and goal-setting (Schellekens et al., 2021; L. Yang & Xin, 2022). In AaL, assessment becomes an ongoing, student-driven process that supports autonomy, critical judgment, and self-efficacy core foundations of metacognitive growth and creativity (Wang & Lee, 2021). In project-based STEM learning environments, AaL is particularly relevant. Open-ended, interdisciplinary tasks require learners to interpret complex issues, generate multiple solutions, and iteratively adjust their strategies. AaL supports these capacities by encouraging students to monitor their thinking, adapt their approaches, and evaluate their learning progress (Gao et al., 2020; Jack R. Fraenkel, Norman E. Wallen, 2011). Yet despite its relevance, AaL remains underutilized in classroom practice, often due to systemic barriers such as limited teacher training, rigid assessment policies, and an entrenched focus on summative testing (He & Wang, 2024; Yan, 2021)

Indonesia's recent curriculum reform, Kurikulum Merdeka, presents an opportunity to operationalize the integration of creativity, STEM, metacognition, and AaL. At the heart of this reform is the Proyek Penguatan Profil Pelajar Pancasila (P5), a project-based learning framework aimed at instilling Pancasila values such as critical thinking, independence, collaboration, and global citizenship (Maryanah et al., 2024; Satria et al., 2024) While P5 is conceptually aligned with the goals of ESD, there is limited empirical research exploring how its teaching materials integrate STEM principles, metacognitive scaffolding, and AaL practices to support creativity. Understanding this integration is vital as schools transition toward competency-based and sustainability-oriented education. This study seeks to investigate how STEM education and metacognitive strategies are embedded in P5 teaching modules and how they contribute to students' creativity within the ESD context. Specifically, the study examines the alignment between the intended curriculum and practical implementation from the perspective of teachers. Using a qualitative design, the study combines document analysis of P5 modules with thematic analysis of teacher interviews to provide a comprehensive view of curriculum content and classroom realities. Applying AaL as an analytical lens allows the study to explore how assessment supports or hinders student creativity and self-regulation in project-based learning.

Theoretically, this study contributes to the growing literature that seeks to connect STEM education, metacognition, and formative assessment with creativity development in sustainability education. By examining how these elements intertwine in curriculum design and classroom practice, the research identifies the pedagogical conditions necessary to foster creative and reflective learners. Practically, the findings offer actionable insights for educators, curriculum designers, and policymakers on how to enhance the design and implementation of P5 teaching materials to better support 21st-century competencies.

2. LITERATURE REVIEW
2.1. STEM Integration in Sustainability-Oriented Education

STEM integration refers to the intentional interconnection of science, technology, engineering, and mathematics to address authentic, complex problems. In sustainability-oriented education, this integration is positioned as an epistemic framework for understanding systemic environmental and societal challenges, enabling learners to reason about interdependencies, leverage cross-disciplinary concepts, and co-create solutions for real-world problems ((Dubek et al., 2024; Mageswary et al., 2022; Noris et al., 2023). Rather than treating disciplines as parallel strands, integrated STEM surfaces the interdependencies among natural, technological, and social systems, aligning closely with the transformative goals of sustainability education (Joseph & Uzondu, 2024; Jue & G., 2019; Karpudewan & Huri, 2022). In sustainability contexts, STEM integration emphasizes multidisciplinary problem framing and the co-creation of solutions, moving beyond superficial disciplinary "add-ons." Reviews and empirical studies consistently highlight real-world problem orientation, student-centered inquiry, and collaborative learning as defining characteristics of meaningful STEM integration (T.-S. Chang et al., 2022; Joseph & Uzondu, 2024; White & Delaney, 2021). Boundary-crossing approaches are particularly emphasized to prepare students for navigating complex environmental challenges that cannot be resolved within single disciplinary silos (Kopbossyn et al., 2025).

Sustainability issues, such as waste management and climate change, demand interdisciplinary reasoning rather than isolated disciplinary knowledge. The studies addressed diverse sustainability challenges, with varying emphases across geographic contexts. Climate dominated topic distributions, followed by water and circularity issues. Biodiversity and energy appeared at moderate levels, while smaller clusters addressed disaster risk, built environment, and justice/policy dimensions (Kopbossyn et al., 2025). The Indonesian context emphasized clean water, sustainable urban solutions, climate action initiatives, and partnerships for sustainable development, explicitly aligned with Sustainable Development Goals 4, 6, 11, 13, and 17 (Sihombing et al.,

2024). Despite these conceptual advances, empirical evidence suggests that STEM implementation often remains activity-driven rather than conceptually integrated. Students may complete engineering design tasks without engaging deeply in scientific reasoning or quantitative analysis, resulting in procedural rather than transformative interdisciplinary learning (Nugraha et al., 2024). This gap indicates that integration at the level of task structure does not automatically ensure epistemic integration at the level of reasoning.

Accordingly, effective sustainability-oriented STEM requires structured problem framing, iterative design cycles, and deliberate opportunities for reflective inquiry (Sihombing et al., 2024). Beyond technical proficiency, it must incorporate aesthetic sensitivity, creativity, and humanistic considerations in responding to environmental challenges (T.-S. Chang et al., 2022; Nipyrakis et al., 2024; Zhan et al., 2022). Therefore, in this study, STEM integration is conceptualized not as a mere combination of disciplinary content but as a structured interdisciplinary approach designed to foster systems thinking, reflective judgment, and solution-oriented reasoning in complex sustainability contexts.

2.2. Metacognitive Regulation

Metacognitive regulation refers to learners' ability to plan, monitor, and evaluate their cognitive processes during task engagement. Rooted in self-regulated learning theory, metacognition functions as a higher-order mechanism that enables adaptive problem-solving and strategic thinking (Hong et al., 2020; Kornreich-Leshem et al., 2022; M. & Sebastian, 2022; Yin et al., 2022). In project-based environments, particularly those involving open-ended STEM challenges, metacognitive regulation is critical (ElSayary, 2021). Learners must determine appropriate strategies, assess the effectiveness of their designs, and revise their approaches based on feedback and evidence. Without explicit scaffolding, however, students may focus on task completion rather than strategic reflection (Liu et al., 2022; Ratnayake et al., 2024; Zhan et al., 2022). Empirical research consistently demonstrates that metacognitive instruction enhances academic achievement, transfer of learning, and critical thinking (Chen, 2020; Puteri & Ardianto, 2023).Within sustainability-oriented projects, metacognitive regulation becomes especially important because students confront uncertainty, conflicting variables, and long-term consequences. Therefore, this study conceptualizes metacognitive regulation as a mediating cognitive process that transforms interdisciplinary engagement into meaningful learning outcomes.

2.3. Creativity in STEM Learning

Creativity in STEM education is increasingly recognized as an essential competency for innovation and sustainable development (B. Yang, 2023). Rather than being limited to artistic expression, creativity in STEM contexts involves generating novel, feasible, and contextually appropriate solutions to complex problems (Ellerton & Kelly, 2021; Susilowati et al., 2020). Within sustainability-oriented STEM projects, creativity entails more than producing novel ideas; it requires balancing originality with ecological integrity, social responsibility, and contextual feasibility (Rebecchi et al., 2024; Rennie, 2021). This dual emphasis on innovation and responsibility is particularly critical in addressing complex twenty-first-century challenges, where solutions must be both inventive and ethically grounded. Creativity in STEM involves regulated engagement of divergent and convergent thinking. Divergent thinking generates multiple ideas, while convergent thinking evaluates, selects, and refines viable solutions. Guilford's historic distinction remains a canonical frame, with contemporary work emphasizing a regulated, cyclical interplay between these two modes as essential for productive creativity in science and engineering contexts (Carbonell et al., 2019; Smeekens & Kane, 2016). In sustainability projects, this regulation is further constrained by ecological and social responsibilities, so viable outputs require balancing novelty with sustainability criteria (Carbonell et al., 2019; Dong et al., 2021; Blatti et al., 2019).

Educational research further indicates that creativity flourishes within learning environments characterized by autonomy support, open-ended problem framing, collaborative inquiry, and constructive feedback (Aquije-Mansilla et al., 2025). Conversely, rigid assessment regimes and highly directive instruction may suppress exploratory thinking and risk-taking behaviors essential for innovative problem-solving (López et al., 2024; Rantanen et al., 2024). Accordingly, in this study, creativity is conceptualized as a developmental outcome emerging from interdisciplinary problem-solving processes that are supported by structured reflection and evaluative practices within sustainability-oriented STEM.

2.4. Assessment as Learning (AaL)

Assessment as Learning (AaL) redefines assessment as an active process through which learners develop self-awareness and evaluative judgment. Unlike summative assessment, which measures achievement at the end of instruction, AaL embeds reflection, self-assessment, and goal-setting within the learning process (Hidayat et al., 2023; Kim, 2024). AaL conceptualizes assessment as an embedded activity where students generate, reflect on, and use assessments to regulate their own learning. This shifts the role of assessment from a measurement moment to a learning process that informs planning, monitoring, and tool use throughout an instructional unit (Lakhtakia et al., 2021; Partiga & Dhoruri, 2024; Yuliaturosida et al., 2025).

Theoretically, AaL aligns closely with metacognitive regulation because both involve monitoring performance and adjusting strategies. By engaging students in analyzing criteria, reflecting on progress, and responding to feedback, AaL fosters cognitive autonomy and responsibility (Fernández-Morante et al., 2022; Xiang et al., 2022) Within STEM-based sustainability projects, AaL plays a critical role in institutionalizing reflection. Without structured assessment mechanisms, reflective practices may remain incidental rather than systematic. Therefore, AaL is conceptualized in this study as the pedagogical infrastructure that supports metacognitive development and sustained creative engagement (Fernández-Morante et al., 2022; Yin et al., 2022; Yuliaturosida et al., 2025).

2.5. Implementation of the Pancasila Student Profile Strengthening Project (P5)

The Pancasila Student Profile Project (P5) constitutes a central pillar of Indonesia's Merdeka Curriculum reform, aiming to cultivate critical thinking, collaboration, independence, creativity, and global responsibility among students. As a character- and competency-oriented initiative, P5 integrates intramural learning, co-curricular projects, and contextual experiences aligned with real-world and environmental issues. Through project-based learning structures, P5 aspires to develop profiling indicators that resonate with sustainability-oriented education principles, particularly in fostering responsible citizenship and adaptive problem-solving(Lailawati et al., 2025; Maryanah et al., 2024; Putri & Nurfuadi, 2025; Sari et al., 2023; Swandana et al., 2023). Embedding STEM approaches within P5 creates strategic opportunities to operationalize these competencies through interdisciplinary problem framing, systems thinking, and evidence-based reasoning. Such integration aligns with the broader goals of sustainability-oriented STEM education, which emphasize the interconnectedness of scientific, technological, and societal dimensions in addressing complex challenges (Metafisika et al., 2022; Sehah et al., 2025; Utami et al., 2023). In this sense, P5 provides a structural platform through which sustainability-driven STEM learning can be enacted within formal curriculum policy.

However, research on curriculum enactment consistently indicates that reform aspirations do not automatically translate into classroom transformation. Implementation is mediated by teacher pedagogical readiness, prevailing assessment cultures, and institutional alignment. Without coherent integration of STEM design, metacognitive scaffolding, creativity facilitation, and Assessment as Learning (AaL) practices, P5 risks being implemented at a procedural level rather than as a transformative learning experience. Therefore, examining how these pedagogical components interact within P5 modules is essential for assessing not merely policy compliance, but the depth and quality of instructional enactment.

3. RESEARCH METHOD

This study employed a qualitative document analysis design to examine how the implementation of the Pancasila Student Profile Project (P5) under the Sustainable Lifestyle theme operationalizes STEM integration, metacognitive strategies, creativity facilitation, and Education for Sustainable Development (ESD) principles. Document analysis was selected because the study aimed to systematically evaluate written implementation reports uploaded by schools to the Merdeka Mengajar Platform (PMM). These reports constitute official institutional artifacts that document pedagogical planning, instructional processes, and project outcomes, thereby providing direct evidence of enacted curriculum practices rather than perception-based accounts. A directed content analysis approach was adopted, as the coding categories were derived from established theoretical frameworks related to sustainability-oriented STEM education. This approach enabled structured evaluation of how conceptual constructs STEM, metacognition, creativity, and ESD—were embedded in authentic implementation practices while maintaining alignment with the study's conceptual framework.

3.1. Data Source and Sampling

The data were obtained from publicly accessible P5 implementation reports submitted by junior secondary schools (SMP) in West Java to the PMM platform. At the time of data collection, 50 reports were available under the Sustainable Lifestyle theme. A purposive sampling strategy was employed to ensure analytic relevance and data richness. From the total 50 reports, 30 modules were selected based on the following criteria:

- Complete documentation of project planning and implementation stages
- Explicit alignment with sustainability-oriented themes
- Detailed descriptions of student learning activities
- Sufficient information to evaluate interdisciplinary integration
- Representation across different districts within West Java

This sampling strategy ensured that the selected reports provided comprehensive and analyzable evidence of implementation practices while maintaining contextual diversity.

3.2. Coding Framework and Rubric

Each module was examined using an analytic rubric designed to assess four primary dimensions, namely STEM integration, metacognitive strategy integration, creativity facilitation, and alignment with Education for Sustainable Development (ESD). The rubric was adapted from a Likert-type scale ranging from 0 to 5, with the

score representing the degree of structural integration reflected in each indicator. Based on this scale, the performance levels were classified into four categories. A score ranging from 3.76 to 5.00 was categorized as Excellent, indicating strong and explicit integration of STEM principles, metacognitive scaffolding, creativity support, and sustainability dimensions. Scores between 2.51 and 3.75 were classified as Good, reflecting substantial integration with only minor gaps in coherence or depth. Scores from 1.26 to 2.50 were considered Moderate, suggesting partial integration accompanied by noticeable conceptual or structural limitations. Meanwhile, scores between 0 and 1.25 fell into the Low category, indicating minimal or absent integration of the evaluated constructs.

The STEM indicators focused on evidence of interdisciplinary problem framing, hands-on investigation, real-world application, and opportunities for critical thinking. Metacognitive indicators examined whether modules incorporated structured planning, monitoring, reflection, and prompts that support students' regulation of learning processes. Creativity indicators evaluated the presence of open-ended tasks, autonomy, iterative design processes, and opportunities for original idea generation. ESD indicators assessed the integration of environmental, social, and economic sustainability dimensions, including contextualized real-world examples and responsibility-oriented learning goals. To enhance analytical consistency, coding definitions were iteratively refined, and category alignment was cross-checked against the theoretical framework.

3.3. Data Analysis

Data analysis was conducted in two stages. First, qualitative coding was applied to each module based on the predefined indicators. Textual evidence within reports was categorized according to the four analytical dimensions. Second, descriptive statistics were calculated to determine the mean and standard deviation for each dimension across the 30 modules. The inclusion of standard deviation allowed identification of variability patterns, enabling interpretation of whether observed trends reflected systemic tendencies or isolated cases.

3.4. Interview Component

To provide contextual understanding of the document analysis results, semi-structured online interviews were carried out with 10 educators who had implemented P5 projects. The interviews examined teachers' perceptions regarding the extent to which the modules supported students' creativity and metacognitive development, along with challenges experienced during classroom implementation. The interview data were used primarily to contextualize and corroborate the findings derived from document analysis rather than being subjected to independent thematic analysis.

4. RESULT AND DISCUSSION

4.1. Quantitative Findings: Rubric-Based Module Evaluation

The analysis of 30 Pancasila Student Project (P5) learning materials focused on the incorporation of Education for Sustainable Development (ESD), STEM motivation, provision of space for creativity, and metacognitive strategies. The implications of the findings have major implications on the development of students' skills, particularly metacognition and creativity. The analysis highlighted areas of gaps in the development of metacognitive skills and creativity, and the incorporation of STEM into education systems that promote sustainability. The findings of the analysis are shown in Table 1 below.

Table 1. P5 Teaching Materials Analysis Results

Aspect	Mean	SD	Interpretation
P5 modules supporting ESD	1.30	0.27	Moderate
P5 modules motivating students toward STEM	1.60	0.20	Moderate
Creativity facilitation	0.50	0.18	Low
Metacognitive integration	1.30	0.04	Low

As shown in Table 1, sustainability themes and references to STEM concepts appear in many of the examined modules. However, these elements are often introduced at a descriptive or contextual level rather than functioning as integral components of an interdisciplinary learning framework. In many cases, sustainability issues are presented primarily as thematic topics, while the instructional design does not fully support inquiry-driven exploration or design-based problem solving. In contrast, opportunities for fostering student creativity appear considerably more limited. Many modules present predetermined activities with clearly defined outcomes, leaving little room for students to generate alternative ideas, experiment with different approaches, or develop original solutions. Similarly, explicit metacognitive scaffolding such as prompts that encourage students to plan, monitor, and reflect on their learning strategies is rarely embedded within the project structure. The limited presence of these elements indicates that reflective and self-regulatory learning processes are not yet systematically integrated into the instructional design of many P5 modules.

Another notable pattern concerns the similarity of findings across different school contexts. Modules from both urban and rural schools demonstrate comparable instructional structures, with only slight variation in the extent to which creativity-related activities are included. In most cases, project tasks remain highly structured and teacher-directed, which restricts opportunities for student autonomy, reflection, and creative experimentation. This pattern suggests that the observed limitations may reflect broader instructional design tendencies rather than differences in school context. In terms of topic distribution, Figure 1 illustrates the thematic focus of the analyzed P5 teaching materials.
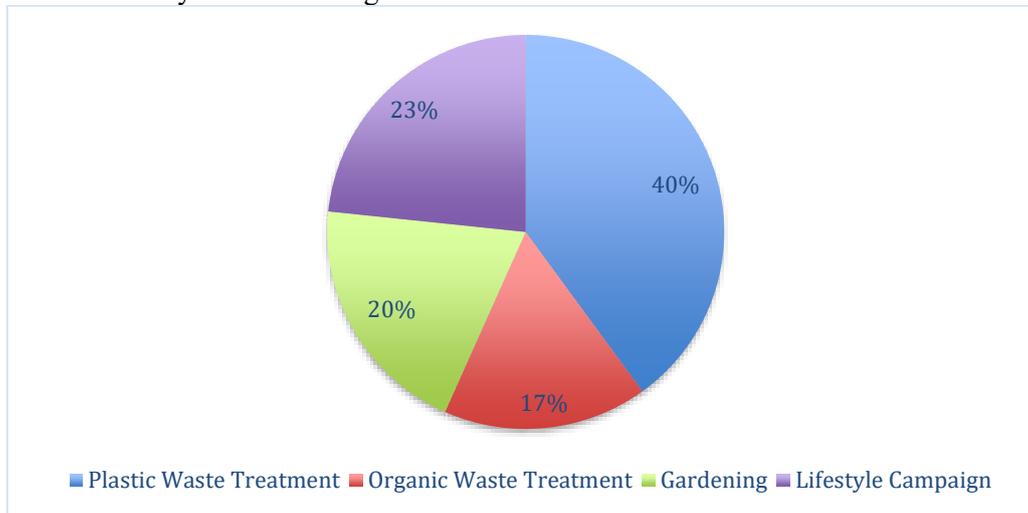

Figure 1. Topic Distribution in P5 Teaching Materials

The distribution indicates that while sustainability is a recurring theme within P5 materials, the thematic scope remains relatively narrow and primarily environmentally focused. Topics such as waste management and environmental cleanliness dominate the project themes. Broader sustainability issues such as climate innovation, circular economy practices, or sustainable technology development are rarely represented. This limited thematic diversity may restrict opportunities for deeper interdisciplinary exploration and creative engagement, which are central objectives of both STEM education and Education for Sustainable Development. These findings suggest that P5 modules tend to emphasize thematic sustainability awareness rather than inquiry-driven interdisciplinary learning. Similar patterns have been reported in previous studies of STEM project implementation, where hands-on activities are present but not always supported by reflective and metacognitive learning structures (Clark et al., 2024; Cloutier et al., n.d.). Without such pedagogical scaffolding, sustainability projects risk becoming procedural activities rather than transformative learning experiences that foster creativity, critical thinking, and metacognitive awareness(Howlett et al., 2016; Leite et al., 2022).

4.2. Qualitative Findings: Thematic Analysis of Teacher Interviews

To complement the document analysis, semi-structured interviews were conducted with ten teachers who had implemented P5 projects in their schools. The interview data were analyzed using thematic coding, resulting in six dominant themes that reflect teachers' experiences in implementing sustainability-oriented P5 modules. These themes primarily relate to limitations in creativity facilitation, challenges in STEM integration, the conceptual treatment of sustainability, and the absence of metacognitive learning practices. The results of the teacher's interview (n = 10) produced six dominant themes:

Table 2. Results of Teacher's Interview

Theme	Axial Code	Example Coding (Teacher Quote)	Percentage (%)
Limited Creativity in Modules	Overly structured tasks	"The P5 module is too tied to specific formats. There are not many chances for students to create original solutions."	40%
	Low student autonomy and initiative	"Students often wait for instructions. There is little initiative because everything is pre-directed in the module."	40%
	Authentic projects increase engagement	"When the task was project-based, students were visibly more enthusiastic and engaged."	70%
	Freedom sparks creative thinking	"When students could choose the form of their projects, they became more creative."	30%

Theme	Axial Code	Example Coding (Teacher Quote)	Percentage (%)
Lack of STEM Integration Guidance	Vague or missing STEM links	"We don't know how to connect the project topics to concrete STEM elements. The module just mentions them without explanation."	30%
Teacher Readiness for STEM	Limited training and conceptual clarity	"Many teachers are still unfamiliar with integrative learning. STEM feels abstract, and not all teachers have had adequate training."	30%
ESD is Merely Conceptual	Superficial treatment of sustainability	"The modules often cover environmental issues, but rarely move into real action. Many just end with posters or slogans."	20%
	Misaligned problems and solutions	"The issues presented are about energy, but the solutions focus on waste. It confuses students."	20%
Lack of Metacognitive Practice	No space for reflection or self-evaluation	"Students are not guided to reflect on their learning processes. Reflection is not embedded deeply in the module."	40%
	Need for Structured Reflection	"Students need clear reflection prompts. For example: What worked? What can be improved?"	40%

The thematic analysis of teacher interviews reveals several structural challenges in implementing Pancasila Student Project (P5) modules in ways that effectively support creativity, metacognition, and STEM integration. Teachers consistently described project activities as highly structured, which constrained opportunities for students to generate original ideas and explore alternative solutions. This finding aligns with previous research suggesting that excessive instructional structure can limit creative thinking because students tend to focus on completing prescribed tasks rather than engaging in divergent problem solving (Leroy & Romero, 2021). Within project-based learning environments, creativity typically emerges when learners are provided with autonomy, open-ended tasks, and opportunities to experiment with multiple solutions (Mubarok et al., 2025). Figure 2 below presents a visual network of the main themes and associated subthemes identified from teacher interviews. This thematic map helps illustrate the interconnections between challenges in creativity, metacognition, STEM integration, and instructional practice.
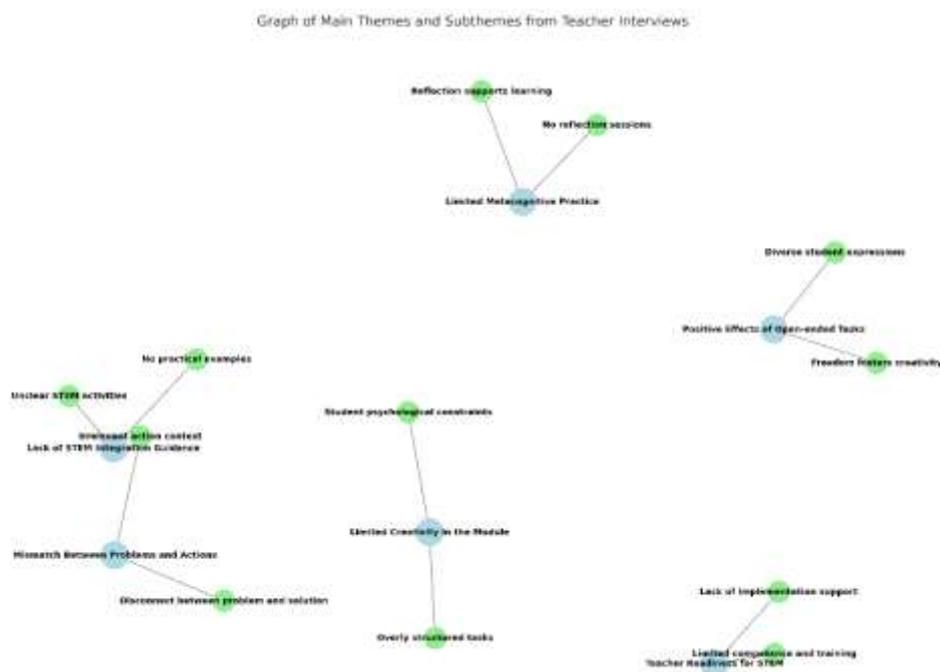

Figure 1. Topic Distribution in P5 Teaching Materials

Teachers further emphasized that authentic project tasks tended to increase student engagement, particularly when learners were allowed to determine the form or direction of their projects. Such observations are consistent with the principles of project-based learning, where authentic, real-world problems can stimulate curiosity and deeper engagement with learning processes (Y. Chang et al., 2024). When students perceive ownership over their work, they are more likely to demonstrate persistence, originality, and intrinsic motivation in problem-solving activities (Ghaemi & Potvin, 2020). Another important theme emerging from the interviews concerns the lack of clear guidance for integrating STEM concepts within P5 modules. Teachers noted that while STEM terminology sometimes appears in the modules, explicit explanations of how scientific, technological, engineering, and mathematical concepts should interact within project activities are often absent. This issue reflects a broader challenge in interdisciplinary STEM education, where teachers frequently report uncertainty about how to design learning experiences that authentically integrate multiple disciplines rather than presenting them as isolated components (Shernoff et al., 2017).

Teacher readiness also emerged as a critical factor influencing the implementation of STEM-oriented learning. Several teachers acknowledged limited training and conceptual understanding related to integrated learning approaches, which may hinder their confidence in facilitating interdisciplinary project activities. Previous studies have highlighted that teacher professional development plays a crucial role in enabling effective STEM pedagogy, particularly in contexts where teachers must adopt new instructional roles as facilitators of inquiry and design-based learning (Dare et al., 2018; Shernoff et al., 2017). The interviews also revealed that sustainability concepts within P5 modules are frequently treated at a conceptual or awareness level rather than translated into authentic problem-solving experiences. Teachers reported that projects often conclude with symbolic outputs such as posters or campaigns rather than actionable solutions addressing real environmental issues. Such findings suggest a gap between the theoretical aims of Education for Sustainable Development (ESD) and its practical implementation in classrooms. According to UNESCO (2017), effective ESD pedagogy should encourage learners not only to understand sustainability challenges but also to develop competencies for critical thinking, systems thinking, and collaborative problem solving.

Another prominent theme concerns the limited presence of structured metacognitive activities within project modules. Teachers noted that students are rarely guided to reflect on their learning strategies, evaluate their problem-solving processes, or monitor their progress during project work. Metacognitive reflection is widely recognized as a crucial component of effective learning because it enables learners to regulate their cognitive strategies and develop deeper conceptual understanding (Schraw & Dennison, 1994). In project-based learning environments, reflective prompts and structured self-evaluation activities can help students become more aware of how they learn, thereby strengthening both metacognitive awareness and problem-solving abilities (.. & Widjajanti, 2025). Overall, the thematic network illustrates how several challenges overly structured tasks, limited STEM integration guidance, insufficient teacher preparation, superficial treatment of sustainability, and minimal metacognitive scaffolding are interconnected. These findings highlight a misalignment between the intended goals of the P5 curriculum and the realities of classroom implementation. The qualitative evidence therefore complements the rubric-based module analysis by providing contextual insights into why creativity and metacognitive practices remain underdeveloped within existing instructional materials.

4.3 Triangulation if Findings: Document vs Teacher Perspective
The absence of formative self-assessment opportunities suggests that Assessment as Learning principles are not yet fully integrated into the module design.

Table 3. Triangulated Evidence from Module Analysis and Teacher Interviews

Theme	Evidence from Module (Rubric Analysis)	Supporting Teacher Quote	Interpretation
Lack of metacognitive strategies	Average score for "Reflection guidance" was 2.1/5	"There's no reflection prompt students don't evaluate how they worked or what they learned."	Both data sources indicate that reflective practices are not systematically embedded in the modules, limiting opportunities for students to develop metacognitive awareness and self-regulated learning.
Limited task creativity	Highly structured tasks dominate with limited choice.	"The module is too fixated on the step."	The structured design of tasks may unintentionally restrict students' creative exploration

Theme	Evidence from Module (Rubric Analysis)	Supporting Teacher Quote	Interpretation
		Students are less likely to experiment."	and reduce opportunities for divergent thinking in project activities.
Misalignment between problem and action	Sustainability topics included, but activities unrelated.	"Digging up the problem of global warming, but the solution and the products offered are to make compost"	This indicates a disconnect between problem identification and solution design, suggesting that sustainability topics are sometimes addressed superficially rather than through authentic problem solving.
Superficial STEM integration	STEM elements present but vague and unscaffolded	"We are confused as to which part is included in engineering or technology."	The lack of explicit guidance for interdisciplinary integration may lead teachers to interpret STEM elements inconsistently during project implementation.
Lack of AaL orientation	Few modules included goal-setting or monitoring activities	"Students just follow without knowing the purpose or evaluation."	The absence of formative self-assessment opportunities suggests that Assessment as Learning principles are not yet fully integrated into the module design.

As shown in Table 3, several patterns consistently emerge across both data sources. Issues related to limited metacognitive scaffolding, rigid task structures, and superficial STEM integration appear both in the rubric-based document analysis and in teachers' classroom experiences. These converging findings suggest that the challenges are not merely related to implementation but are also embedded within the design of the learning modules themselves.

4.4 Implications for STEM, Creativity, and Metacognition in P5

The findings of this study provide several important implications for improving the design and implementation of Pancasila Student Project (P5) modules, particularly in relation to creativity development, STEM integration, and metacognitive learning practices. The triangulated results indicate that although the modules aim to support project-based and interdisciplinary learning, several structural elements within the current design may limit their effectiveness in fostering higher-order thinking and student autonomy. The findings highlight the need to redesign project activities in ways that better support student creativity. The current modules tend to emphasize structured procedures and predetermined outputs, which may unintentionally restrict opportunities for divergent thinking. Creativity-oriented learning environments require open-ended problems, flexible task structures, and opportunities for students to explore multiple solution pathways (Shodiq et al., 2025; Tromp, 2024). In the context of P5 implementation, project tasks could be redesigned to allow students greater autonomy in defining project goals, selecting materials, and determining the form of their final products. Such design principles are consistent with constructivist approaches to project-based learning, which emphasize student agency and authentic problem solving (Ali et al., 2024).

The results suggest that clearer guidance is required for meaningful STEM integration within P5 modules. While references to STEM elements appear in the learning materials, explicit connections between science, technology, engineering, and mathematics are often insufficiently articulated. Effective STEM education requires interdisciplinary learning experiences that connect conceptual knowledge with design processes and real-world problem solving (Daugherty & Carter, 2018; Nugraha et al., 2024). To address this issue, curriculum developers may consider incorporating structured design-thinking frameworks, engineering design cycles, or inquiry-based STEM activities that help teachers and students navigate interdisciplinary learning processes more effectively. The findings emphasize the importance of embedding metacognitive practices more systematically within project activities. Metacognitive learning strategies such as goal setting, progress monitoring, and reflective evaluation play a crucial role in helping students regulate their learning processes and develop deeper conceptual understanding (Rhodes, 2019; Schraw & Dennison, 1994). However, the analysis indicates that reflection and self-assessment opportunities are not consistently integrated into the current modules. Incorporating structured reflection prompts, learning journals, and peer feedback activities

could strengthen students' metacognitive awareness and support the development of self-regulated learning skills. Strengthening teacher professional development is essential to support the effective implementation of interdisciplinary project-based learning. Teachers reported challenges in interpreting STEM elements and facilitating open-ended project activities, suggesting that instructional materials alone may not be sufficient to support curriculum innovation. Previous research has shown that successful implementation of STEM and project-based learning largely depends on teachers' pedagogical content knowledge and their confidence in facilitating inquiry-based learning environments (Mansour et al., 2024; Tucker et al., 2024). Therefore, professional development programs focusing on STEM pedagogy, design-based learning, and reflective teaching practices may help teachers translate curriculum intentions into meaningful classroom experiences.

Despite these contributions, several limitations should also be acknowledged. The study is based on the analysis of a limited number of P5 modules and teacher interviews within a specific educational context, which may limit the generalizability of the findings to other regions or schools. In addition, the study primarily examines curriculum design and teacher perceptions rather than directly observing classroom implementation or measuring student learning outcomes. Future research could therefore extend this work by conducting classroom-based studies that investigate how redesigned modules influence student creativity, problem-solving skills, and metacognitive development over time. Overall, the findings suggest that strengthening the alignment between curriculum design, teacher support, and classroom practices is essential for realizing the transformative goals of the P5 curriculum. By integrating creativity-supportive task design, clearer STEM scaffolding, and structured metacognitive reflection, P5 modules have the potential to more effectively support interdisciplinary learning and prepare students with the competencies needed to address complex real-world challenges.

5. CONCLUSION

This study explored how Proyek Penguatan Profil Pelajar Pancasila (P5) modules support the development of creativity, STEM integration, and metacognitive learning by combining rubric-based document analysis with thematic analysis of teacher interviews. The findings suggest that while the modules incorporate project-based activities and sustainability themes aligned with the goals of the P5 curriculum, several aspects of their design and implementation still require improvement. The quantitative analysis indicates that some important elements—such as structured reflection, clear interdisciplinary STEM connections, and formative assessment practices—are not yet fully integrated into the modules. These findings are supported by teachers' perspectives, which highlight practical challenges in facilitating creative project work, interpreting STEM components, and guiding students through reflective learning processes. When considered together, the results suggest that the limitations observed in classroom practice are closely related to how the modules themselves are designed. These findings point to the importance of strengthening the alignment between curriculum design, instructional guidance, and classroom implementation. To better achieve the intended goals of the P5 curriculum, future module development should provide more opportunities for open-ended project exploration, clearer scaffolding for interdisciplinary STEM learning, and structured reflection activities that encourage students to think about and evaluate their own learning processes. In addition, ongoing professional development is essential to support teachers in facilitating interdisciplinary and inquiry-based learning environments. This study also has several limitations that should be acknowledged. The analysis focused on a limited set of modules and teacher perspectives within a particular educational context, which may limit the broader generalization of the findings. Moreover, the study did not directly examine classroom practices or measure student learning outcomes during project implementation. Future research could therefore expand this work by investigating how improved module designs influence students' creativity, problem-solving abilities, and metacognitive skills in real classroom settings. Overall, this study contributes to the ongoing discussion on curriculum innovation and interdisciplinary learning in Indonesian education. By identifying key gaps in the current design of P5 modules and highlighting the experiences of teachers who implement them, the findings offer useful insights for curriculum developers, educators, and policymakers seeking to strengthen the impact of project-based learning within the P5 framework.

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