
Baseline Analysis of Students' Creativity in Particle Dynamics for Designing a STEM-Integrated PjBL E-Modul

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ABSTRACT

Low creativity levels among high school students in physics learning remain a persistent challenge requiring evidence-based instructional responses. Unlike prior baseline studies focused on other physics topics, this study addresses an unexplored gap: student creativity profiles in the particle dynamics topic as an empirical foundation for a STEM-integrated PjBL e-module. A quantitative descriptive design was employed involving 108 eleventh-grade students from three intact classes (XI F1, XI F2, XI F3) at a public senior high school in West Sumatra. Data were collected using a 12-item essay creativity test measuring fluency, flexibility, originality, and elaboration based on Guilford's framework. The instrument was validated through expert content validity review, item difficulty analysis, discriminating power analysis, and reliability estimation using Cronbach's alpha prior to administration. Scores were categorized into five levels: very low (≤ 54), low (55–59), sufficient (60–75), high (76–85), and very high (86–100). The overall mean creativity score was 58.57 (low category); 83.34% of students fell below the sufficient threshold and none reached high or very high levels. Fluency was the strongest indicator ($M = 61.57$, sufficient) while flexibility was the weakest ($M = 54.40$, very low). Class XI F3 exhibited the greatest variability ($SD = 15.91$) whereas XI F2 was the most consistent ($SD = 12.27$). These findings provide a data-driven baseline for developing a PjBL-STEM e-module that scaffolds tasks progressively from fluency to elaboration, incorporates differentiated pathways, and emphasizes multi-perspective problem-solving to address the critical weakness in flexibility.

Keywords: *creativity, e-module, project based learning, stem, physics learning*

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INTRODUCTION

Creativity stands as a fundamental skill in contemporary education, allowing students to think across multiple perspectives when faced with complex problems ([Suherman et al., 2025](#)). More than just generating ideas, creativity involves the capacity to actively formulate, evaluate, and improve concepts to create meaningful and workable solutions ([Khalil et al., 2023](#)). Schools now recognize that fostering creative thinking is essential for preparing students who can adapt and innovate in an increasingly digital world. The challenge of developing students' creativity is not merely an academic concern but a practical necessity for equipping the next generation with competencies demanded by the 21st-century workforce.

In physics education, particularly when studying particle dynamics, students must grasp conceptual understanding rather than merely memorizing procedures. However, classroom observations reveal that many students struggle with applying creative thinking to physics problems. What often happens is that students memorize formulas and computational steps without truly comprehending the underlying concepts ([Irvaniyah et al., 2025](#)). This approach leaves them unable to handle unfamiliar problems or situations that demand creative problem-solving. Prior to implementing active learning strategies, students exhibited low critical thinking skills with a pre-test mean of 50.18, and teacher-centered methods produced minimal student engagement and below-threshold learning outcomes ([Yati et al., 2024](#)). Traditional classroom practices that center on the teacher's role appear to limit how much students develop genuine creative and critical abilities. Despite the growing body of research on student creativity in Indonesian physics classrooms, prior studies have predominantly focused on topics such as dynamic fluids ([Irvaniyah et al., 2025](#)) and momentum ([Saputri et al., 2022](#)) leaving the specific creativity profile of students studying particle dynamics largely unexplored. Moreover, no prior study has systematically linked a creativity baseline in this topic area to the concrete design features of a STEM-integrated PjBL e-module. This gap makes the present study both distinctive and necessary.

One promising instructional model is Project Based Learning (PjBL), especially when integrated with STEM fields (Science, Technology, Engineering, Mathematics). This approach engages students in active, team-based learning by having them apply academic knowledge to real challenges ([AlAli, 2024](#); [Chang et al., 2024](#)). In PjBL classrooms, learners confront authentic, meaningful problems that require thorough analysis, sound judgment, and inventive solutions ([de la Torre-Neches et al., 2020](#)). Evidence confirms that such problem-based methods help students improve their creative skills, problem-solving abilities, and interest in science ([Babalola & Keku, 2024](#); [Ilhami & Mahendra, 2024](#)). PjBL significantly improved student activity across two cycles, from quite active (54%) to very active (92%), and increased classical learning completeness from 62% to 92%, confirming PjBL as an effective student-centered approach ([Wati et al., 2024](#)).

The global research landscape further supports the urgency of developing PjBL-STEM instructional materials. A bibliometric analysis of 329 Scopus-indexed publications from 2012 to 2025 documented a significant annual growth rate of 25.03% in research on integrated PjBL-STEAM learning, with Indonesia ranking first in total citation contributions, indicating strong national research engagement with this approach. PjBL-based digital teaching materials are effective in enhancing students' active engagement, conceptual understanding, and contextual learning experiences, while explicit integration of ESD in physics teaching materials on topics such as renewable energy remains limited indicating an ongoing research opportunity ([Yuliyanti et al., 2025](#)). When STEM elements are integrated, students tend to show higher engagement and motivation ([Hakim et al., 2025](#)).

Before designing an e-module using PjBL and STEM integration, it is important to first understand students' starting point in terms of creativity. Gathering this baseline information helps educators choose suitable learning strategies and content that address actual student requirements ([Fitri Fatimah et al., 2024](#); [Ginting & Amdayani, 2024](#)). Initial assessment of student abilities provides the foundation for creating teaching approaches that genuinely fit student circumstances ([Dinantika et al., 2021](#)). The current study was undertaken to examine how creative grade XI students were when working with particle dynamics material. This study pursued four

main goals: (1) to determine creativity levels across four dimensions: fluency, flexibility, originality, and elaboration; (2) to compare creativity across classes and indicators; (3) to determine the percentage of students in each creativity level; and (4) to derive implications for designing a PjBL-STEM e-module that strengthens student creativity. This study constitutes the needs-analysis phase of a broader instructional development cycle and does not include design, validation, or implementation of the e-module itself. The e-module development will be reported in a subsequent study.

METHOD

This study employed a quantitative descriptive research design to analyze and document students' creativity levels in learning particle dynamics. The quantitative descriptive approach was selected because the primary purpose was to provide an accurate, systematic, and numerical account of students' baseline creativity without applying any experimental manipulation. A descriptive-survey design has similarly been applied to analyze students' critical thinking skills as a foundation for developing physics instructional materials, positioning baseline analysis as a prerequisite step before the development phase ([Ahzari & Akmam, 2025](#)). Descriptive research is appropriate when the goal is to document existing conditions of a population or phenomenon and to draw implications for instructional design ([Saputri et al., 2022](#)). The study proceeded through three sequential stages: (1) instrument preparation and validation, (2) data collection through a structured creativity test, and (3) descriptive statistical analysis and interpretation to inform e-module design.

The study was conducted during the first semester of the 2024/2025 academic year at a public senior high school in West Sumatra Province, Indonesia. The school was purposively selected because the topic of particle dynamics was being taught during the data collection period, ensuring alignment between the research instrument and ongoing classroom instruction. The participants consisted of 108 eleventh-grade students from three intact classes (XI F1, XI F2, and XI F3), with 36 students in each class. Purposive sampling was employed because participant selection was based on their engagement with the particle dynamics topic at the time of data collection rather than on random selection procedures. This approach is consistent with needs-analysis studies in physics education, where participant selection is guided by curriculum relevance rather than population representativeness ([Ahzari & Akmam, 2025](#)). All students in the three selected classes participated in the study, yielding a total sample of 108 participants.

Instrument Development and validation

Data were collected using a creativity test specifically developed for this study to measure four key dimensions of divergent thinking theoretical framework ([Guilford, 1967](#)): (1) fluency, defined as the capacity to generate numerous relevant ideas or solutions within a limited time, assessed by counting distinct valid responses per item; (2) flexibility, defined as the ability to shift cognitive perspective or approach when solving a problem, measured by the variety of qualitatively different answer categories a student produced; (3) originality, defined as the generation of ideas that are unusual, novel, or statistically infrequent compared to the responses of the overall group, evaluated based on the uniqueness of each response relative to the full dataset; and (4) elaboration, defined as the capacity to enrich or develop an idea with additional detail and depth, scored based on the extent and quality of students' elaborations. Fluency, flexibility, originality, and elaboration constitute the primary measurable dimensions of creative thinking in science education, as confirmed by a meta-analysis of physics teaching materials ([Ahzari et al., 2026](#)). The instrument consisted of 12 essay items (3 items per indicator), each scored using a 4-point rubric (0–3), with items designed to reflect real-world particle dynamics scenarios requiring open-ended responses to enable assessment of divergent thinking across all four indicators.

Before it was used, the instrument went through a validation process. Content validity was established through expert panel review by two physics education specialists ([Lawshe, 1975](#)); item difficulty analysis was conducted targeting a p-value range of 0.30–0.70; discriminating

power analysis used a minimum discrimination index of 0.30; and reliability was estimated using Cronbach's alpha to ensure internal consistency of the creativity scores. All 108 students from three classes completed the creativity test during a single, simultaneously administered 90-minute testing session. Prior to the test, the researcher provided a standardized briefing explaining the study's purpose, the nature of the creativity test, and the specific instructions for responding to each item type. Students were explicitly instructed that there were no single correct answers and that original, elaborated responses were encouraged. Each student completed the test individually and independently, without access to textbooks, notes, or peer assistance, to ensure that the responses reflected each student's unaided creative thinking. Test administration was supervised by the subject teacher and the researcher to maintain standardized conditions across all three classes. Scoring was performed using a rubric calibrated to each of the four creativity indicators. Raw scores for each indicator were converted to a 0–100 scale to enable comparability across indicators and classes. The composite creativity score for each student was calculated as the arithmetic mean of the four indicator scores.

Categorization Framework

Scores were categorized into five levels: very low (≤ 54), low (55–59), sufficient (60–75), high (76–85), and very high (86–100). These boundaries were not derived from Guilford's theoretical framework, which describes the four creativity dimensions but does not specify numerical cut-off scores. Instead, the categorization adapts the hypothetical-score approach commonly used in Indonesian educational research, in which boundaries are set relative to the obtainable score range and the empirical distribution of student scores on the instrument (Azwar, 2012). Within this approach, category widths are not required to be equal, as they reflect the concentration of scores observed within specific bands of the 0–100 scale for this particular instrument and sample. The same five-level categorization framework and cut-off criteria were used consistently across all classes and indicators, ensuring transparency and comparability of findings.

Data Analysis

Data were analyzed using descriptive statistics, including mean, median, mode, standard deviation, variance, range, minimum, and maximum, computed separately for each class and for each creativity indicator using Microsoft Excel. Frequency distributions and percentages were computed to determine the proportion of students falling within each category. Because the primary purpose was descriptive documentation of a baseline condition rather than group comparison, inferential statistical tests were not conducted. All cross-class and cross-indicator comparisons in this study are therefore treated as exploratory and descriptive rather than confirmatory, and the closely clustered class means (a span of only 1.22 points) should be interpreted as indicating broadly similar performance across classes rather than statistically established equivalence.

RESULT AND DISCUSSION

Creativity Performance Across Classes

To understand how students performed overall and whether differences existed between classes, [Table 1](#) presents this comprehensive picture.

Table 1. Descriptive statistics of creativity scores by class

Statistic	XI F1	XI F2	XI F3	Overall
Mean	58.85	59.03	57.81	58.57
Standard Error	2.07	2.04	2.65	2.25
Median	56.25	62.50	59.38	59.38
Mode	50.00	62.50	75.00	62.50
Standard Deviation	12.44	12.27	15.91	13.54
Sample Variance	154.85	150.55	253.07	183.33
Range	50.00	62.50	50.00	62.50
Minimum	31.25	25.00	31.25	25.00
Maximum	81.25	87.50	81.25	87.50
Sum	2,118.75	2,125.00	2,081.25	6,325.00

The average score across all 108 students was 58.57 (SD = 13.54), placing them in the low category. The three classes showed closely clustered averages: XI F2 scored highest at 59.03, followed by XI F1 at 58.85, and XI F3 at 57.81, a span of only 1.22 points. Despite these similar means, variability within each class told a different story. Class XI F3 exhibited notably greater spread (SD = 15.91, Variance = 253.07), suggesting wide differences in creativity among its students. In contrast, class XI F2 showed the most uniform performance (SD = 12.27, Variance = 150.55), while XI F1 fell between the two. Low and highly variable initial competencies among students in science subjects are a common challenge that should directly inform the design of instructional interventions (Wiyono et al., 2025). Designing instructional materials that accommodate this variability through scaffolded and tiered activities is therefore essential for reaching all learners effectively.

Class XI F2 showed the broadest score range (62.50), spanning from a low of 25.00 to a high of 87.50, indicating the presence of both very weak and very strong performers within the same class. Its median of 62.50 was noticeably higher than those of XI F1 (56.25) and XI F3 (59.38), meaning more than half of XI F2 students scored at or above the lower boundary of the sufficient category. This internal diversity within classes suggests that a differentiated instructional approach, not a one-size-fits-all strategy, is needed when deploying the e-module. Because no inferential statistical test was conducted for class comparisons, the observed differences in means and variability should be interpreted descriptively and treated as exploratory observations rather than confirmed group differences.

Performance on Individual Creativity Dimensions

While overall averages provide a general picture, analyzing performance across the four specific creativity dimensions reveals students' strengths and weaknesses more clearly. This indicator-level view is critical for shaping the pedagogical emphasis of the e-module. [Table 2](#) presents the breakdown for each class and overall.

Table 2. Student creativity scores by indicator

Indicator	XI F1	XI F2	XI F3	Average (Category)
Fluency	63.19	57.64	63.89	61.57 (Sufficient)
Flexibility	54.17	59.03	50.00	54.40 (Very Low)
Originality	58.33	63.89	56.25	59.49 (Low)
Elaboration	59.72	55.56	61.11	58.80 (Low)
Average	58.85	59.03	57.81	58.57 (Low)

Fluency, the ability to produce many ideas, was the strongest area, averaging 61.57 and reaching the sufficient level. When asked to generate solutions, students could generally produce a reasonable quantity. The critical weakness was flexibility, which averaged only 54.40, falling into the very low category. Flexibility demands shifting perspectives when encountering new situations, a skill students found considerably challenging. Originality and elaboration both fell in the low range at 59.49 and 58.80, respectively. These results paint a picture of students who can generate a number of ideas but struggle with viewing problems from multiple angles, producing novel solutions, and developing ideas in depth.

Distribution of Students by Creativity Category

Beyond descriptive statistics, examining how many students fell into each creativity category offers a more direct answer to the question of whether current instruction adequately develops creative abilities. [Table 3](#) shows this distribution across all 108 students.

Table 3. Distribution of students by creativity category

Category	Number of Students	Percentage
Very Low	38	35.19%
Low	52	48.15%
Sufficient	18	16.67%
High	0	0%

Very High	0	0%
Total	108	100%

The distribution carried a striking message: 83.34% of all students performed below the sufficient level. Specifically, 35.19% fell into the very low category and 48.15% into the low category. Notably, not a single student reached the high or very high categories. This result underscores a systemic deficiency in how creativity is currently being developed in physics learning.

Category Distribution by Class

While the overall distribution was uniformly low, examining class-level distributions provides more granular insights. [Table 4](#) reveals distinct patterns across XI F1, XI F2, and XI F3 that carry practical implications for how the e-module should be differentiated.

Table 4 . Distribution of students by category and class

Category	XI F1	XI F2	XI F3	Total
Very Low	10 (27.78%)	12 (33.33%)	16 (44.44%)	38 (35.19%)
Low	19 (52.78%)	17 (47.22%)	16 (44.44%)	52 (48.15%)
Sufficient	7 (19.44%)	7 (19.44%)	4 (11.11%)	18 (16.67%)
High	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Very High	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Total	36 (100%)	36 (100%)	36 (100%)	108 (100%)

Class XI F1 had the lowest proportion of students in the very low category (27.78%), with 52.78% in low and 19.44% reaching sufficient. Class XI F2 showed a somewhat more encouraging distribution: 33.33% very low, 47.22% low, and 19.44% sufficient, equal to XI F1 in sufficient performance. Class XI F3 presented the most challenging profile: 44.44% very low, 44.44% low, and only 11.11% sufficient, the lowest proportion of any class. These class-level differences suggest that XI F3 students need the most intensive scaffolding and support, while XI F2 students, who also include a maximum score of 87.50, contain learners already capable of reaching higher levels of creative performance. An adaptive e-module design that provides variable levels of guidance and challenge is therefore justified and necessary.

Implications for E-Module Design

Based on the indicator-level results in [Table 2](#), each creativity indicator was mapped to a PjBL-STEM syntax stage, a project task type, a scaffolding strategy, and a digital feature of the e-module (see [Table 5](#)).

Table 5. Design matrix: creativity indicators mapped to PjBL-STEM e-module features

Creativity Indicator	PjBL-STEM Syntax Stage	Project Task Type	Scaffolding Strategy	Digital Feature
Fluency (M=61.57, Sufficient)	Start the Challenge	Open brainstorming: generate as many solutions as possible for a particle dynamics problem	Idea checklist; quantity-first instruction	Digital idea board; auto-count of responses
Flexibility (M=54.40, Very Low)	Design & Plan	Multi-perspective analysis: solve one problem using science, technology, engineering, math lenses	Perspective-shift cue cards; gallery walk comparing approaches	Branching scenario menu; forced perspective- switching before next stage unlocks
Originality (M=59.49, Low)	Create & Build	Novel prototype: design a solution not yet seen in provided examples	Novelty rubric shown in advance; peer rating of uniqueness	Novelty flag comparing submission to class pool; originality tracker

Creativity Indicator	PjBL-STEM Syntax Stage	Project Task Type	Scaffolding Strategy	Digital Feature
Elaboration (M=58.80, Low)	Communicate & Reflect	Detailed project report: justify every design decision with physical principles and data	Structured elaboration template with "explain why" prompts at each step	Feedback engine highlights underdeveloped sections; revision tracker

Discussion

This study set out to describe the creativity of grade XI students in particle dynamics, compare it across classes and indicators, determine the share of students at each creativity level, and derive implications for a PjBL-STEM e-module. The overall picture is one of low creativity: the mean fell in the low category and no student reached the high or very high categories. Creativity is a fundamental skill that allows students to approach complex problems from multiple perspectives (Suherman et al., 2025), and it involves formulating, evaluating, and improving concepts into workable solutions (Khalil et al., 2023). Against this expectation, the observed baseline suggests that current physics learning gives students limited opportunity to develop this capacity. This is consistent with the view that creativity, as a form of divergent thinking, needs purposeful instructional design and does not arise spontaneously from passive learning environments (Lengo & Djami, 2019). Meta-analytic evidence likewise shows that conventional physics instruction tends to yield below-expected creative and critical thinking outcomes (Sastra et al., 2022).

Because this study did not observe classrooms or interview teachers, the following explanation is a plausible contextual interpretation and not a confirmed cause. Indonesian high school physics classrooms have been described as relying heavily on teacher-led instruction and procedural practice (Ahzari & Akmam, 2025; Irvaniyah et al., 2025). Students in such settings often memorize formulas and computational steps without grasping the underlying concepts, which leaves them unable to handle unfamiliar problems that demand creative problem solving (Irvaniyah et al., 2025). A focus on algorithmic problem solving, typical in preparation for high-stakes examinations, may also discourage the flexible, multi-perspective thinking that creativity requires. Related evidence points the same way. Yati et al. (2024) reported that before active learning strategies were introduced, students' critical thinking, a competency closely related to creativity, stood at a low pre-test mean of 50.18 under teacher-centered methods. The low creativity baseline found here is consistent with this pattern, although only systematic observational or interview data can establish a direct link. The results also complement earlier work on other physics topics such as dynamic fluids (Irvaniyah et al., 2025) and momentum (Saputri et al., 2022) by showing that low creativity is also evident in particle dynamics, a topic that had received little attention. The pattern across topics suggests that the limitation may lie in how physics is commonly taught, more than in any single topic.

The indicator profile shows that students can generate ideas more readily than they can vary, originate, or develop them. This aligns with Guilford's (1967) conception of divergent thinking, in which fluency is generally the easiest dimension to activate, while flexibility and originality require deliberate cognitive cultivation (Lengo & Djami, 2019). Flexibility involves shifting perspective when encountering new situations, and routine, single-method problem solving gives students few chances to practice it, which may explain why it was the weakest indicator. Its low score also matters because flexibility underpins the ability to think across multiple perspectives that Suherman et al. (2025) identify as central to creativity in contemporary education. Broader evidence supports the view that such capacities are developable. Reviews report that creative reasoning, collaboration, and flexible problem solving remain underdeveloped under conventional instruction but can be strengthened through PjBL-STEAM approaches (Yuliyanti et al., 2025). Problem-based methods have also been shown to improve students' creative skills, problem-solving abilities, and interest in science (Babalola & Keku, 2024; Ilhami & Mahendra, 2024). Taken together, this suggests that flexibility and originality can be improved, but only

when tasks are introduced through scaffolded activities of gradually increasing cognitive demand, not at full complexity from the start.

The near-identical class means mask meaningful differences in spread and distribution. XI F3 combined the greatest variability with the largest share of very low performers and the smallest share of sufficient performers, indicating a wide gap between learners that would be hidden if only averages were reported. XI F2, by contrast, included both the lowest and highest individual scores, showing that even a low-scoring class contains students capable of stronger creative performance. Because no inferential test was run, these class comparisons are exploratory and should not be taken as confirmed group differences. Even so, low and variable initial competencies are a common challenge in science learning and should directly inform the design of instructional interventions ([Wiyono et al., 2025](#)). This supports gathering baseline information before designing instructional materials, so that strategies and content address actual student needs ([Fitri Fatimah et al., 2024](#); [Ginting & Amdayani, 2024](#)) and fit student circumstances ([Dinantika et al., 2021](#)). A one-size-fits-all approach would likely under-serve both the weakest and the strongest learners, which supports differentiated instruction with tiered support, where more structured guidance is given to weaker students while stronger students explore more independently ([Peng et al., 2022](#)).

The design matrix in Table 5 translates these interpretations into features of the PjBL-STEM e-module, which addresses the gap identified in the background by linking a creativity baseline in particle dynamics to concrete design features. Since most students were below the sufficient level, the module begins with accessible fluency-level tasks, such as open brainstorming of solutions to a particle dynamics problem, and moves gradually toward flexibility, originality, and elaboration tasks. This sequencing follows Bloom's Revised Taxonomy, which progresses from lower-order competencies (remember, understand, apply) to higher-order competencies (analyze, evaluate, create) ([Anderson & Krathwohl, 2001](#)). PjBL is a suitable vehicle for this progression because it engages students in active, team-based learning where academic knowledge is applied to real challenges ([AlAli, 2024](#); [Chang et al., 2024](#)), and because authentic problems call for thorough analysis, sound judgment, and inventive solutions ([de la Torre-Neches et al., 2020](#)). Since flexibility was the weakest indicator, the multi-perspective analysis task is central to the design. It asks students to explore multiple solution pathways and to link particle dynamics concepts to technological, engineering, and mathematical contexts at once, which is the kind of perspective shifting STEM integration is meant to encourage. Originality and elaboration are supported through novelty criteria shared in advance and structured "explain why" prompts that push students to justify design decisions with physical principles and data. Given the wide spread within classes, particularly XI F3, the branching activities and optional support features in the matrix provide tiered guidance suited to different readiness levels.

Cognitive development is also closely tied to motivation and engagement, which the design deliberately addresses. Students tend to show higher engagement and motivation when STEM elements are integrated ([Hakim et al., 2025](#)), and PjBL-based digital teaching materials have been reported to enhance active engagement, conceptual understanding, and contextual learning experiences ([Yuliyanti et al., 2025](#)). Evidence from classroom action research also shows that PjBL can raise student activity and learning completeness ([Wati et al., 2024](#)), and that learning motivation rose from 45.45% to 96.65% after two cycles of PBL ([Wiyono et al., 2025](#)). Applied to this study, an e-module built around real-world STEM problems and collaborative projects may foster similar benefits for creativity, although this needs empirical testing. Finally, because classes with similar means differed in their distributions, scaffolding options, multiple entry points, and adaptive difficulty are built into the module's architecture so that teachers can deploy it across diverse classroom contexts.

CONCLUSION

This study concludes that students' creative thinking in particle dynamics is underdeveloped and that current instruction does not appear to give it adequate support. The profile is one of relative strength in generating ideas alongside marked weakness in adapting perspectives, producing original solutions, and developing ideas in depth. Averages alone are not a sufficient guide to

instruction, since classes that look alike on average differ considerably in how their students are distributed. As the needs-analysis phase of a broader development cycle, the study establishes a baseline that justifies a PjBL-STEM e-module and shapes its design. The module should scaffold learners progressively from idea generation toward flexible, original, and well-elaborated thinking. It should offer differentiated pathways so students of different readiness can all be reached. And its STEM-integrated projects should emphasize multi-perspective problem solving, which is the most promising route to strengthening the weakest creative capacity. These principles provide the foundation for the design, validation, and implementation phases to be reported in a subsequent study. The study has two main limitations: instructional context was not directly measured, and class differences were not tested inferentially. Future research should add classroom observation and teacher interviews to clarify why creativity is low, and should test whether the developed e-module improves students' creativity after implementation.

CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest.

AUTHOR CONTRIBUTIONS STATEMENT

Conceptualization, P.I.P. and Y.; methodology, P.I.P. and Y.; validation, Y. and F.M.; formal analysis, P.I.P.; investigation, P.I.P.; data collection, P.I.P.; data curation, P.I.P. and F.N.; interpretation of the research findings, Y., F.M., and F.N.; writing, original draft preparation, P.I.P.; writing, review and editing, Y., F.M., and F.N.; supervision, Y.; project administration, P.I.P. All authors have read and agreed to the published version of the manuscript.

AI DISCLOSURE STATEMENT

The authors used ChatGPT (OpenAI) during the preparation of this manuscript for language refinement, grammatical improvement, and assistance in improving the clarity and organization of the manuscript. After using the tool/service, the author thoroughly reviewed and edited the content as needed and takes full responsibility for the content of the publication. The authors declare that this research was prepared, researched, written, and edited without the aid of artificial intelligence (AI) techniques.

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