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Constraints in teaching scientific creativity in K-12 STEM physics classroom

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ABSTRACT

Scientific creativity is essential to science, technology, engineering, and mathematics (STEM) education; however, students' creativity remains relatively low as revealed by international large-scale assessments, particularly in K-12 physics classrooms. Despite its importance, limited studies have examined the specific constraints that hinder the development of scientific creativity in the Philippine STEM contexts. This study aimed to identify the underlying constraints affecting teaching and learning of scientific creativity. An exploratory qualitative research design was employed. Semi-structure interviews were conducted with six STEM teachers, and the data were analyzed using thematic analysis. The results from the analysis were substantiated by literature review for triangulation of qualitative findings. Three major themes emerged from the analysis: i) time constraints, which limit opportunities for inquiry, experimentation, and design-based activities; ii) curriculum constraints, characterized by congested and rigid curriculum with limited interdisciplinary integration; and iii) pedagogical and assessment constraints, marked by teacher-centered instruction and assessment practices that prioritize content mastery over creativity. These findings underscore the systemic barriers that restrict the cultivation of scientific creativity in classrooms. Consequently, the study suggests the need for greater curriculum flexibility, creativity-aligned pedagogy, and alternative assessment approaches to better support the development of scientific creativity among STEM learners.

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1. INTRODUCTION

Scientific creativity has been recognized as a critical component of science, technology, engineering, and mathematics (STEM) education, essential for developing learners' capacity to solve complex problems, generate innovative ideas, and apply scientific knowledge in novel contexts [1]. Recent studies characterize scientific creativity as a multidimensional construct encompassing fluency, flexibility, originality and scientific usefulness, positioning it as both cognitive and pedagogical outcome of science learning [2], [3]. International frameworks e.g. next generation science standards, UNESCO's national curriculum framework and large-scale assessments, e.g. Organisation for Economic Co-operation and Development (OECD) Programme for International Student Assessment (PISA) science framework, emphasize the importance of creativity alongside conceptual understanding and inquiry skills in science learning [4]. These frameworks collectively prompt a paradigm shift in science education from transition of content towards innovation oriented, learner centered knowledge construction [5]. As education systems increasingly aim to prepare students for rapidly evolving scientific and technological challenges, the integration of scientific creativity into school science curricula has become a shared priority across countries. This global emphasis underscores the importance of examining how creativity-oriented goals are translated into classroom practice, particularly in developing educational systems where curriculum reforms are still evolving.

The transition from revised basic education (RBEC) to the K-12 education framework marked major reform in Philippine science education [6], particularly in physics teaching and learning. This reform was intended to align Philippine education with global standards emphasizing depth, coherence, and relevance to learning experiences. A key innovation of the K-12 science curriculum is the spiral progression approach, where core concepts across science disciplines are revisited with increasing complexity [7], [8]. While the structure aims to strengthen understanding, it also presents challenges in embedding scientific creativity as an explicit and sustained instructional goal [6], [9], [10]. Previous studies suggest that without deliberate pedagogical and curricular support, spiral progressions risks become repetitive rather than generative of new ideas [11], [12]. Consequently, examining how teachers interpret and implement the spiral progression approach becomes essential in understanding whether the curriculum structure supports or constrains opportunities for creative scientific thinking in physics classrooms.

The spiral progression approach is designed to deepen conceptual understanding through repeated exposure and real-life applications of physics concepts such as motion, force, energy, and momentum [13]. These learning experiences ideally require opportunities for inquiry, experimentation, and creative problem-solving [14], [15]. However, the curriculum's emphasis on content coverage often limits time and flexibility for open-ended tasks, creating a gap between the intended development of higher-order skills and actual classroom practices. This tension between curriculum breadth and creativity-oriented represents critical instructional issues for physics teachers. Investigating these tensions is important because teachers play an important role in cascading the curriculum expectations and classroom realities [16], particularly when balancing the conceptual coverage with opportunities of inquiry and innovation.

Alongside curriculum restructuring, the K-12 science framework promotes student-centered approaches such as inquiry-based, problem-based, and interdisciplinary learning [17]–[19]. These approaches are closely linked to the development of scientific creativity, as they encourage questioning, investigation, and idea generation [20]–[22]. Despite this alignment in theory, scientific creativity is not explicitly emphasized in curriculum standards or assessment, and in actual implementation, resulting in inconsistent integrations across physics classrooms. This lack of explicit curricular articulation weakens teachers' capacity to intentionally design creativity-focused learning experiences. As a result, the absence of clear curricular guidance may lead teachers to prioritize content mastery and standardized assessment requirements over activities that foster creativity and innovation [23]. These pedagogical realities are essential in identifying areas where curriculum support and teacher professional development may be needed.

Results from PISA 2022 highlight the urgent need to innovate the Philippine curriculum to address low scientific creativity. Filipino students scored 14 points in creative thinking, far below the OECD average of 33, placing the country among the lowest performance globally. This outcome suggests that content curriculum and classroom practices may insufficiently promote creativity, inquiry, and idea generation [10], [24]. Such findings underscore systematic issues rather than an isolated classrooms shortcoming. It is essential to understand the instructional, curricular, and assessment-related sources of these low scores to inform curriculum redesign and creativity-focused educational reforms [6]. These findings further emphasize the relevance of investigating classroom-level experiences to determine how structural and pedagogical factors may contribute to the limited development of scientific creativity among Filipino learners. This study can provide a context-specific perspective by examining how these systemic issues are manifested within K-12 physics classrooms. It further distinguishes itself by linking large-scale assessment findings with teachers' experiences to identify curricular and pedagogical challenges to scientific creativity.

Given the critical role of teachers translating curriculum goals into classroom practice, examining how scientific creativity is addressed in K-12 physics education is essential. Although creativity is recognized as an important 21st-century skill, there remains limited empirical evidence on how it is taught and constrained within the current curriculum. This lack of empirical clarity constitutes a significant research gap, particularly in physics education within developing country contexts. The resolution of this gap is important because identifying the specific constraints encountered by teachers can provide insights for improving curriculum implementation and instructional practice. This study seeks to address this gap by exploring the challenges in teaching scientific creativity in K-12 physics classrooms to inform curriculum improvement and instructional practice. In identifying curricular, pedagogical, and assessment-related constraints from teachers' perspectives, this study offers novel, context-sensitive contribution that can guide evidence-based curriculum enhancement and professional development initiatives focused on scientific creativity. This study aimed to explore the development of scientific creativity in K-12 STEM physics

classrooms identifying key constraints and analyzing how these barriers limited teaching practices and hinder learners' ability to develop scientific creativity. Specifically, it sought to answer the following questions:
- What constraints affect the teaching and learning of scientific creativity in K-12 STEM physics classroom?
- How do these constraints hinder the development of scientific creativity in the classroom?

2. METHOD
2.1. Research design
This study employed qualitative exploratory research design grounded in a generic qualitative inquiry approach to examine the challenges in teaching scientific creativity in K-12 STEM classrooms. A qualitative approach was deemed appropriate as it allowed for an in-depth exploration of teachers' experience, perceptions, and practices related to scientific creativity [25], [26]. A generic qualitative inquiry design was selected because the study aimed to understand the participants' perspectives and experiences without adhering strictly to the philosophical assumptions of traditions such as phenomenology, grounded theory, or ethnography [27], [28]. Instead, the focus was on describing and interpreting teachers' views regarding the constraints affecting scientific creativity in physics classroom.

The study focused on understanding contextual and systemic constraints rather than measuring variables, making qualitative inquiry suitable for capturing rich and nuanced insights from participants. Moreover, an exploratory design is particularly appropriate when a phenomenon under theorized and not sufficiently examined in a specific educational context, as in the case with scientific creativity in K-12 physics education, enabling surface patterns, meanings, and constraints grounded on participants lived classroom realities. This design aligns with the objectives of the study identifying instructional, curricular, and assessment-related constraints experienced by STEM teachers in fostering scientific creativity.

2.2. Participants of the study
The participants of this study were selected using purposive sampling to ensure that those included had direct and relevant experience in teaching scientific creativity within the K-12 physics contexts. Inclusion criteria required teachers to be currently teaching or have recently taught senior high school physics under the STEM strand, with at least 3 years of teaching experience. Participants must have experience in designing or assessing physics activities such as experiments and projects, be actively employed in school implementing the K-12 curriculum. Based on the selection criteria, six teachers as shown in Table 1 qualified for semi-structure interviews and had provided their consent to participate. The sample size was determined through principle of data saturation, wherein participants recruitment continued until no new themes, insights, or categories emerged from the qualitative data.

Table 1. Basic information about the teacher participants

Teacher	Gender	Educational attainment	Institution	Subject specialization	Experience (in years)
A	F	Master's Degree Holder	Public	Physics	6
B	F	Master's Degree Holder	Public	Chemistry and Physics	7
C	M	Master's Degree Units Earner	Private	Physical Science	4
D	M	PhD Degree Units earner	Private	Physical Science	12
E	M	Master's Degree Units Earner	Public	Physics/General Science	14
F	M	Master's Degree Holder	Private	Physics and Mathematics	14

2.3. Data collection and analysis
Data collection was conducted through individual semi-structured interviews, which were audio-recorded with participants' consent and later transcribed verbatim. Each interview lasted for about 30 minutes highlighting their issues and concerns in teaching scientific creativity in K-12 physics classroom on STEM strand. The interview guide is a researcher-developed which was validated by science education and qualitative research experts for validity and appropriateness for the study and participants. The expert validators examined clarity, relevance, and alignment to research objectives. They provide feedback on wordings, sequencing, and scope of the questions to ensure that they will capture the teachers' views and experiences to scientific creativity.

Thematic analysis was used to analyze the interview transcripts. The analysis followed an iterative coding process informed by commonly accepted qualitative analytics procedure [29]. First, familiarization with the data by repeatedly reading the transcribe interviews to gain understanding their experiences to the phenomenon under observation. During this stage, a manual review using initial analytic memos was initiated to capture emerging insights and guide subsequent coding. Second, coding significant statements describing teachers' experiences, instructional decisions, and perceived learning constraints in fostering creativity among STEM learners were done manually. The third is identifying recurring patterns and themes, where related codes were grouped as potential recurring themes addressing the research question of the study. The themes were refined and organized to represent the major constraints in teaching scientific creativity. A review of related literature was also conducted to support and contextualize the emerging themes, enhancing the credibility and trustworthiness of the findings. The sample size of six STEM teachers was considered sufficient for this exploratory qualitative study, as it enabled in-depth analysis and reached data saturation where no new themes emerged. To enhance credibility, member checking was conducted by returning interpretations to participants for validation. Likewise, peer validation was undertaken with a qualitative research expert to review the coding and thematic analysis.

3. RESULTS AND DISCUSSION

In identifying the underlying factors that contribute to the relatively low scientific creativity of the students both in person and product viewpoints, qualitative method of data collection was employed in conducting semi-structured interviews of six STEM teachers. This allowed to gain the teachers' perspectives on the challenges they encountered in teaching and learning scientific creativity. In a similar manner, a literature review was initiated to further support the findings uncovered from the exploratory qualitative research conducted with selected STEM teachers. In the qualitative data analysis of the interview transcript, three common themes were uncovered that summarized the challenges encountered by the teachers in teaching scientific creativity among the students as presented in Figure 1.

Table 2 shows the summary of thematic analysis of the semi-structured interview with STEM teachers revealing the three major themes in Figure 1. Each theme is further broken down into categories and specific codes that capture the underlying issues as expressed by the teacher-informant. Table 2 summarizes these themes, categories, and codes, providing a clear overview of the challenges encountered in fostering scientific creativity in K-12 STEM physics classroom.

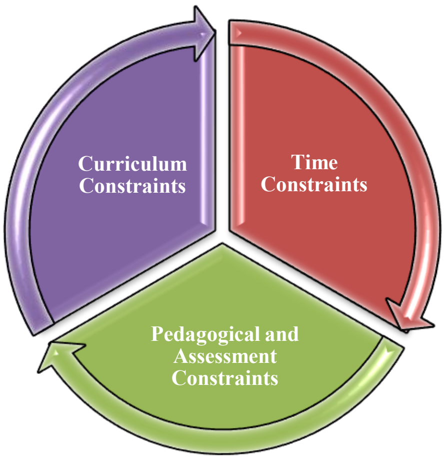

Figure 1. Constraints in teaching scientific creativity in K-12 physics classroom on STEM strand

3.1. Time constraints

Instructional time is a significant component that provides students with the opportunity to learn. The time allotment is a significant factor in the teaching and learning of scientific creativity in STEM education. The time dedicated to the subjects influences the depth and breadth of exploration, experimentation, and problem-solving opportunities available to the students. In the Philippine setting, science instruction is given a time allotment for a maximum of 158 hours per annum [30]. The DepEd Order no. 32, s. 2012 provided guidelines regarding time allotment per subject, where science courses require 4 sessions per week, each session lasted for 50 minutes. In total, there are 4 hours of instructional time per week at basic education level. According to the teacher-informants, development of scientific creativity requires ample time for exploration and investigation, which usually involve trial and error methods. As a result, the teacher-informants resorted to teaching the content of the syllabus as it is, leaving no room for the students to perform activities that are open-ended in nature and design-based creative projects.

Table 2. Themes, categories, and codes of constraints in fostering scientific creativity

Theme	Category	Codes
Time constraints	Limited instructional time	Insufficient class periods; short session duration; inability to complete project
	Curriculum coverage pressure	Rushing lessons; prioritizing syllabus completion; reduced exploratory activities
	Competing academic and administrative demands	Teacher seminar; documentation of workload; student requirement and submissions
	Disrupted instructional continuity	Class suspensions; cancelled classes; poor lesson sequencing
Curriculum constraints	Congested curriculum content	Broad scope of the curriculum; broad goals and objectives
	Prescriptive learning outcome	Fixed competencies; most essential learning competencies (MELCs)-driven instruction; limited flexibility
	Limited interdisciplinary integration	Compartmentalized teaching; weak STEM integration; gaps in foundation math and science skills
	Insufficient instructional resources	Lack of laboratories; limited equipment; absence of creative materials
Pedagogical and assessment constraints	Teacher-centered instructional practices	Lecture-dominated class; knowledge transmission approach
	Limited engagement	Passive learning environment; minimal inquiry and experimentation
	Traditional assessment methods	Pen-and-paper tests; concept recall; concept-focused exams
	Grade-oriented learning culture	Students' fixation on grades; limited qualitative feedback; creativity not assessed

Furthermore, due to the same problem, the teacher-informants are prompted to focus on delivering the curriculum content rather than engaging in an in-depth understanding of the underlying principles and connection of science concepts. For instance, hands-on activities that provide students opportunities to investigate, examine, and experiment in real-life problems, which eventually lead to the development of creative thinking, are also not prioritized. In the grassroot level, the teacher-informants claimed that the theoretical content is given more premium than practical applications. Theories and conceptual content are more prioritized over practical skills development due to the conformity of the schools to standardized assessment tools, which are laid down by the national and local agencies. The teachers are compelled to prepare the students to take the standardized examinations, where the assessment standards focused more on recalling and understanding facts and information.

> "*Really, it's about time. We have time, but it's limited, and it's not possible. For example, doing the project, it can't be done in one period. There's really a process – from planning and consultation to proper execution.*" (Teacher A)
> "*They need to develop their creativity through the thinking process. So, the things that hinders me from developing it – like time, of course, the students – not all of them are open in the process, so it requires a lot of time to enhance the skills.*" (Teacher B)
> "*At the moment, there are many things the students to comply with, to submit, to attend to, while us teachers we have seminars to attend to, requirements and documents needed to submit. These are the normal things that bother a teacher in teaching creativity.*" (Teacher C)
> "*Time constrained. Many activities, cancellation of classes, failure to plan along suspension of classes. I opted not to inject creativity and resort to direct teaching especially if the examination is approaching. Given enough time, I can still give discovery method.*" (Teacher D)

3.2. Curriculum constraints

The learning barriers associated with the curriculum have a significant impact on teaching and learning of scientific creativity in STEM education. These constraints are attributed to the curriculum content, scope, and the sequence of the topics. One of the main reasons why scientific creativity is not given priority in STEM education, as cited by the teacher-participants, is the congested curriculum which requires the teachers to deliver within a limited timeframe. As such, the teacher-participants claimed that it is their priority to cover as many topics as they can, adhering to the curriculum guidelines. This results in a more rigid and conventional way of learning, which does not highlight the autonomy of the students on their own learning. In addition to this, the learning outcomes are fixed from the curriculum which specify the standards and objectives the students needed to learn after the content coverage.

Based on the narratives of the teacher-informants, this situation often led to delimiting the students pursuing their interest, asking their own questions, and engaged in a self-directed learning task. While the curriculum content was stripped to MELCs, the teacher-informants still argued that there are still necessary pre-requisite skills and competencies that need to be addressed before teaching the curriculum content itself. Given this situation, they narrated that they still teach the learning topics and objectives prior to teaching the prescribed topics from the curriculum. In view of this, the science subjects in STEM education are usually taught in a compartmentalized manner that lacks significant integration from other disciplines, making it interdisciplinary. It is contended that STEM as a discipline is interdisciplinary in nature; hence, interconnection, intersection, and relation across field are inherently important to emerge creativity of the students. The teacher-informants also lamented that it is particularly challenging to implement the curriculum due to lack of training support, teaching resources, and learning materials that support creativity-promoting activities. For instance, lack of science laboratories and scientific tools and equipment constrained the teacher-informants in performing creative projects, experimentation, and laboratory investigations.

> "*The curriculum from the Department of Education feels like a shot in the dark. It's very difficult for me, and it's the same for other schools. I also ask what topics they're covering and where they are in the curriculum. The scope of General Physics 1 and 2 is very broad. That's my issue with those who are in charge view this. The curriculum guide suggests that they expect students to be well-equipped with all the skills from junior high school.*" (Teacher D)
> "*Since we need to cover the DepEd curriculum, we no longer focus on creativity development. It requires time to develop it, and the process is lengthy. For us, we need to finish the curriculum, so they are prepared for higher years.*" (Teacher F)

3.3. Pedagogical and assessment constraints

The pedagogical and assessment practices of the teachers are an important element in fostering scientific creativity in STEM classroom. The pedagogical and assessment methods employed, that are not aligned to the goal of cultivating creativity, imposed limitations on achieving the said goal. In a classroom setting where teachers need to deal with different types of students, who require various pedagogical strategies. According to the teacher-informant, to cover more curriculum content, traditional teaching which focused on rote learning emerged to be the frequently used instruction to the students. Lecture method discussion underscores the delivery of the content, where the teachers assumed most of the responsibility of the students learning. The teacher acts as knowledge transmitter rather than a facilitator. This leaves no room for the students for active engagement, experimentation, hands-on activities, and questioning, which are essential strategies in scientific creativity. Teacher-informants shared that a passive learning environment hinders the students' ability to develop critical thinking and problem-solving required to enhance scientific creativity. Moreover, the teacher-informant argued that the assessment tools they employed usually are pen-and-paper methods, which are convenient to use and implement. These assessment methods often give more premium on memorization and understanding of facts more than applying knowledge in real world scenarios. This form of assessment method discourages the students from thinking creatively. Likewise, the teacher-informants also lamented that most of the students are determined to get higher grades. According to them, students are very particular about the quantities grades that they will get. The teacher-informants said that they give less priority on qualitative feedback and evaluation which will provide students with important insights regarding their learning gains and skills.

> "*We have curriculum that we follow for teaching physics in STEM. That's why we resort to the recommended activities in the curriculum to comply with the curriculum standards.*" (Teacher A)
> "*There are many ideas when it comes to creativity. That's really part of teacher's job, especially with inquiry-based approaches. You need to manage it so that the students' ideas don't diverge or spread too much.*" (Teacher C)
> "*I think the assessment tool that we use to determine students' performance don't measure creativity either. Mostly, assessment tool focus on students' conceptual understanding and problem-solving knowledge in physics.*" (Teacher E)

The teacher-participants reported limited instructional time significantly hindered opportunities for creative exploration, inquiry, and extended hands-on activities in the physics classroom. This aligns with the existing research showing that creative teaching often requires additional time beyond what is typically allocated for routine content delivery, making it difficult for teachers to balance curriculum demands with creativity-focused tasks [31], [32]. In Asian context study, teachers similarly noted that creative lessons frequently took longer time than expected [6], often conflicting with tight curricular schedules and leaving teachers to squeeze creative activities in limited periods or assign them as homework [33], [34]. Moreover, literature on creativity education emphasizes than when time is insufficient, teachers tend to resort to more efficient, teacher-centered approaches that prioritize coverage over deep engagement [35], thereby constraining opportunities for students to engage in iterative scientific problem solving crucial from creative development. In the context of scientific creativity, these temporal constraints inhibit students' capacity to formulate diverse ideas, evaluate alternative explanations, and enhance solutions via experimentation, activities linked to essential aspects of creativity, including fluency, flexibility, and originality. These dimensions, often recognized in models of scientific creativity, necessitate iterative engagement with scientific problems, a challenge exacerbated by rigid time constraints in classroom instruction.

Another major theme was overwhelming and rigid nature of curriculum, which participants felt forced them to prioritize content coverage at the expense of creative inquiry. This reflects broader findings in STEM education research showing that congested curricula focus heavily on predetermined standards and outcomes, leaving minimal flexibility for open-ended, student-driven exploration [6]. Systematic reviews of STEM teaching practices also identify curriculum challenges as a key barrier to implementing integrated and creativity-oriented instructions, with teachers struggling to reconcile interdisciplinary and inquiry-based learning approaches with compartmentalized subject structures [36], [37]. As a result, students' autonomy to pursue their own questions and interests, an essential element of creative learning, is often constrained by fixed learning sequence and rigid assessment expectations, thus limiting opportunities for creative thinking in scientific contexts. From a theoretical perspective, fostering scientific creativity necessitates learning environments that facilitate exploration, idea generation, and the application of scientific knowledge in innovative contexts. When curricula prioritize linear content progression and standardized learning outcomes, teachers may find their ability to create activities that foster creative processes constrained [38]. This inflexible structure is one of the reasons why creativity-related problems keep happening in STEM classrooms.

The third theme highlights how traditional pedagogical and assessment practices can inhibit scientific creativity. Teachers reported that lecture-based instruction and pen-and-paper assessments consistently emphasize memorization and content recall rather than authentic problem solving and creative thinking. Research supports this view, noting that conventional instructional approaches and quantitative assessments tools often fail to capture and encourage creativity, particularly in STEM subjects where creative problem-solving and application of knowledge to novel contexts are central [39], [40]. Similarly, literature on STEM integration emphasizes that without professional development and support for creative pedagogies, teachers may default to familiar method that align with standardized testing, rather than adopting student-centered, inquiry-based strategies that fosters creativity and critical thinking [40], [41]. Consequently, assessment practices that prioritize factual accuracy over creative application may inadvertently discourage students from engaging deeply with content in ways that would nurture originality and innovation. This finding also shows a bigger trend in many education systems, where standardized testing pressures affect how teachers choose to teach [42]. In these kinds of settings, teachers may focus on measurable outcomes that are related to factual knowledge instead of more complex and harder-to-measure parts of learning, like creativity and innovation.

These three themes suggest that constraints related to time, curriculum, and pedagogy are interconnected and collectively shape the classroom environment in ways that limit scientific creativity. Limited instructional time and congested curriculum reinforce teacher reliance on traditional, content-focused pedagogy and assessment, reducing opportunities for students to engage in extended problem-solving, experimentation, and reflective practice, activities shown in the literature to support creative thinking. Furthermore, systemic pressures from curriculum standards and assessment regimes can overshadow creativity-oriented learning goals, leading teachers to prioritize compliance over innovations. The multifaceted constraints should be addressed through coordinated efforts to reframe curriculum design, provide professional learning for creative pedagogies, and adopt assessment practices that value creative process and outcomes alongside mastery. In theory, these factors can be seen as a system that reinforces each other, the rigidity of the curriculum puts more pressure on teachers to cover more material, which leads to the use of efficient but teacher-centered teaching and testing methods. These choices for teaching and testing make it even harder for students to ask creative questions, which keeps a cycle going that stops scientific creativity from growing in physics classrooms.

4. CONCLUSION

The results of the study reveal that the teaching of scientific creativity in K-12 STEM classroom is constrained by three major and interconnected factors namely time limitation, curriculum demands, and pedagogical and assessment practices. Limited instructional time restricts opportunities for inquiry, experimentation, and design-based learning, which are essential for nurturing creativity. At the same time, the congested and rigid curriculum prioritizes content coverage and standardized outcomes, leaving minimal space for student autonomy and interdisciplinary integration. These constraints are further reinforced by traditional teacher-centered pedagogies and assessment methods that emphasize memorization and conceptual recall rather than creative application, thereby limiting students' development of scientific creativity. These findings directly address the purpose of the study, which is to examine the constraints encountered by physics teachers in fostering scientific creativity in K-12 physics classroom. Overall, strengthening scientific creativity in physics education requires systematic shift from content-driven instruction towards learning environment that actively cultivate inquiry, imagination, and innovation.

Based on these results, it is recommended that curriculum planners and school leaders provide greater flexibility in content delivery to allow teachers to implement creativity-enhancing strategies such as inquiry-based, project-based, and design-based learning. Professional development programs should focus on equipping teachers with pedagogical and assessment approaches aligned with scientific creativity, including performance-based and formative assessments. Furthermore, assessment system should value creative process and outputs alongside conceptual understanding. The study encountered limitations including a small purposive sample of six teachers, reliance solely on semi-structured interview and teachers' perspective, and focus on physics classroom, which may limit generalizability of the findings. Future studies may investigate the implementation of targeted instructional models or interventions designed to address these constraints and evaluate their impact on students' scientific creativity in STEM classrooms.

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C : **C**onceptualization	I : **I**nvestigation	Vi : **Vi**sualization
M : **M**ethodology	R : **R**esources	Su : **Su**pervision
So : **So**ftware	D : **D**ata Curation	P : **P**roject administration
Va : **Va**lidation	O : Writing - **O**riginal Draft	Fu : **Fu**nding acquisition
Fo : **Fo**rmal analysis	E : Writing - Review & **E**diting	

CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest regarding the conceptualization, planning, implementation, and publication of this study.

INFORMED CONSENT

Informed consent was obtained from all participants involved in the study.

ETHICAL APPROVAL

The study strictly adhered to appropriate ethical protocols in accordance with the rules and regulations of Laguna State Polytechnic University.

DATA AVAILABILITY

The data that support the findings of this study are available from the corresponding author, [AAEP], upon reasonable request.

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