# From Curiosity to Creation: Cultivating a Culture of Inventiveness in Science Education

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**Abstract**
The PISA 2022 results indicate that there was no significant improvement in the science performance of Filipino students. Persistent gaps in scientific literacy and innovation-related competencies indicate a need to enhance instructional practices and learning environments. This exploratory study determined how higher education institutions facilitate the development of students from curiosity to creation by examining the instructional practices, learning environments, and institutional strategies. There were 20 purposively sampled college students who participated in one-on-one interviews. Narratives were analyzed using reflexive thematic analysis, which helped in identifying critical themes related to culture of inventiveness. Analysis indicated that higher education institutions had developed a culture of inventiveness in science education through the consistent use of inquiry-driven, experiential, and student-centered teaching approaches. Instruction was largely grounded in inquiry- and problem-based learning, experiential activities such as laboratory work and simulations, and flexible, open-ended tasks that promoted student autonomy, collaboration, and creativity in solving real-world scientific problems. In addition, institutions strengthened inventive thinking through guided experimentation, collaborative scientific reasoning, and opportunities for students to independently design procedures, test hypotheses, and interpret results. These practices were further supported by science fairs, innovation exhibitions, laboratory resources, and academic mentorship, which collectively provided platforms and guidance for developing and showcasing innovative outputs. Nevertheless, embedding inventive thinking within classroom culture can directly address the gaps in scientific literacy identified in large-scale assessments. These changes can reorient science learning toward deeper understanding and skill mastery, which in turn improves students' capacity to meet minimum proficiency standards.
Keywords: classroom culture, inventiveness, innovation, science education, science learning

**Introduction**

In the 2022 Programme for International Student Assessment (PISA) results, only about one in four students (23%) achieved Level 2 or higher in science, a proportion that is substantially below the OECD average of 76% (OECD, 2023). A large proportion are not yet able to consistently interpret, evaluate, or apply scientific information in even routine or familiar contexts. This suggests a significant gap in essential scientific literacy skills, which are necessary for informed decision-making and meaningful engagement with scientific concepts in everyday life.

In the Philippine setting, science competence may be positioned beyond conceptual knowledge to include the ability to apply scientific principles in real-world problem-solving, idea generation, and adaptation to unfamiliar contexts. Despite this, persistent gaps in scientific literacy and innovation-related skills suggest the need to strengthen instructional practices and learning environments that explicitly develop inventive thinking, inquiry skills, and active participation in knowledge construction within and beyond the classroom.

Science education is increasingly framed around innovative culture and inventive thinking. Samodra et al., (2026) noted some key concepts related to science education that include projects, methods, creativity, critical thinking, inquiry-based learning, project-based learning, classroom practice, thinking, evaluation, model-building, implementation frameworks, metacognition, curricular integration, innovation, adaptive learning, and evidence-based practice. It also covers mental processes such as thinking, memory, attention, and problem-solving, which are essential for scientific reasoning and application in complex contexts (Mat & Jamaludin, 2024).

Difficulties in science learning among Filipino students may arise from weak foundational knowledge, low science self-efficacy, and limited exposure to environments that promote curiosity, creativity, and inventive thinking. For example, many learners may struggle to connect abstract scientific concepts to real-life situations due to insufficient hands-on laboratory experiences and limited opportunities for inquiry-based learning. In some classroom settings, instruction remains highly teacher-centered, which reduces students' chances to ask questions, engage in experimentation, and develop independent problem-solving skills.

Innovative culture in science education involves a systemic environment shaped by institutional practices, leadership, and classroom interactions that collectively promote experimentation, adaptability, and knowledge creation (Ou et al., 2024). Complementarily, inventive thinking refers to the integration of creative and critical thinking skills to generate innovative solutions to complex problems (Garner et al., 2021; Patel et al., 2024), enabling learners to approach scientific challenges with flexibility, reduced reliance on trial-and-error, and the ability to reframe problems in novel ways (Ng et al., 2026).

Being inventive is understood as a broader human capacity combining creativity, higher-order cognition, curiosity, risk-taking, and self-regulation to produce innovative solutions to complex problems with sociocultural awareness (Ng et al., 2026). This highlights that cultivating inventiveness in science education requires both institutional support and learner-centered experiences that nurture innovation-oriented competencies.

**Literature Review**

Innovation, defined as the practical application of creative ideas, has become an essential process for organizations striving to remain competitive in the global landscape of the 21st century (Fuad et al., 2022). Organizations that effectively integrate innovation into their operations are more likely to enhance efficiency, increase productivity, and strengthen their overall competitiveness.

Studies revealed that an innovative culture serves as a strong predictor of an organization's overall innovativeness (Ahmed, 2025; Fuad et al., 2022). Within such a culture, members of the organization are more likely to feel empowered, supported, and motivated to pursue creative decisions and experiment with new approaches in addressing problems (Fuad et al., 2022).

The current study explored how a meaningful culture should be implemented in higher education to develop students' creative skills. Although the concept of culture is widely researched, Fuad et al. (2022) emphasized that there are still many dimensions of culture, including values, norms, beliefs, and underlying assumptions, need to be clearly articulated. Hence, this study was expected to fill the gap regarding the application of culture in science learning, with emphasis on instructional strategies, peer interaction, and learning processes.

International assessments reveal a serious and persistent problem in Filipino students' science performance. It was reported that only approximately 23% of students attained Level 2 or higher in science, which is considerably below the OECD average of 76% (OECD, 2023). Moreover, despite the four-year interval since the 2018 assessment, there was no significant improvement in student performance, as the proportion of learners scoring below the baseline proficiency level (Level 2) remained largely unchanged across mathematics, reading, and science. At this minimum proficiency level, students are expected to identify correct explanations for familiar scientific phenomena and apply basic scientific knowledge to determine, in simple situations, whether a conclusion is supported by the given data. This indicates that a large majority of Filipino students struggle to achieve even the essential level of scientific literacy required for interpreting and using scientific information effectively (Bernardo et al., 2023).

An effective science education should be grounded in an innovative culture and inventive thinking that encourages continuous improvement, creative thinking, and the exploration of new ideas and approaches in teaching and learning science. In a bibliometric analysis of Ou et al. (2024), an innovative culture is related to concepts such as organizational culture, innovation dynamics, strategic innovation, innovative leadership, transformation, and collaboration. Innovative culture in science education can be understood as a systemic environment where institutional practices, leadership decisions, and classroom interactions collectively support experimentation, adaptability, and knowledge creation.

Meanwhile, inventive thinking operates at the cognitive level as it involves the integration of creative and critical thinking skills to develop innovative or specially designed solutions (Garner et al., 2021; Patel et al., 2024). Across studies, inventiveness is consistently linked to creativity, innovation, and effective problem-solving, particularly in addressing complex and non-routine scientific tasks. Proficiency in inventive thinking enables learners to solve problems efficiently with reduced dependence on trial-and-error approaches, while also allowing them to reframe problems and approach scientific challenges from alternative or unconventional perspectives (Ng et al., 2026).

Being inventive is conceptualized as an inherent human capacity that, when systematically developed, integrates creativity, higher-order cognition, and dispositional traits such as curiosity, risk-taking, and self-regulation, enabling individuals to generate innovative solutions to complex and novel problems with sociocultural awareness (Ng et al., 2026). As such, the cultivation of inventiveness in science education might be dependent on both structured institutional practices and learner-centered experiences that collectively support the development of innovation-oriented competencies.

Ng et al. (2026) identified the need for a clearer and more unified understanding of inventive thinking and being inventive as a global educational concern, particularly in addressing the lack of standardized frameworks for innovation-related competencies. In the Philippine context, being competent in science not only requires students to demonstrate conceptual understanding and knowledge, but also to apply scientific principles in solving real-world problems, generating ideas, and adapting to complex and unfamiliar situations.

Students are expected not only to understand scientific facts but also to engage in inquiry, design solutions, and participate in knowledge creation within and beyond the classroom. However, persistent gaps in scientific literacy and innovation-oriented skills suggest the need to strengthen instructional practices and learning environments that explicitly cultivate inventive thinking.

**Objectives**

This study explored how higher education institutions cultivate culture of inventiveness for science education. It focused on exploring experiences, practices, and processes to identify effective measures for learning and skills development. Below are the specific objectives of the study.

1. To explore the practices and strategies employed by higher education institutions in cultivating a culture of inventiveness within science education.
2. To describe the experiences and perspectives of learners regarding the development of creativity, innovation, and inventive thinking in science learning environments.

**Methodology**

***Research Design***

A qualitative research design was applied to gain an in-depth understanding of how higher education institutions cultivate a culture of inventiveness in science education. Specifically, an exploratory research design was used to understand the practices, experiences, and perspectives of learners regarding the development of creativity, innovation, and inventive thinking within science learning environments. This enabled the study to uncover emerging patterns, institutional approaches, and contextual factors that contribute to building a culture of curiosity, inquiry and innovation (Chavez, 2025).

***Participants and Sampling***

Purposive sampling was designed to identify and select the participants in this study. Purposive sampling helps select participants who possess specific characteristics, experiences, or knowledge relevant to the phenomenon being studied (Ahmad & Wilkins, 2025). It is useful in qualitative research because it allows gathering rich, detailed, and meaningful information from individuals. A criterion was established: (1) currently enrolled in a science-related course (e.g., biology, chemistry, agriculture, or other science disciplines); (2) exposed to learning environments or institutional practices that promote a culture of inventiveness; (3) have participated in science-related activities, projects, or tasks involving creativity, inquiry, experimentation, or innovation; (4) have experiences with instructional approaches that encourage problem-solving and scientific exploration; (5) willing to share their perspectives and experiences regarding inventiveness in science learning; and (6) able to communicate their experiences clearly through interviews. There were 20 college students who participated in this study.

***Research Instrument***

A semi-structured interview guide was designed to gather narratives from the participants in one-on-one interviews. This is a set of prepared guiding questions that helped in providing flexibility to probe further, clarifying responses, and exploring emerging ideas during the interviews (Chavez et al., 2026). **Table 1** presents the interview questions used in the one-on-one interviews, organized according to each specific research objective.

**Table 1.** Interview guide used in gathering the narrative data

| **Objective** | **Interview Questions** |
|---|---|
| To explore the practices and strategies employed by higher education institutions in cultivating a culture of inventiveness within science education. | 1. How do your science teachers design or conduct lessons that encourage creativity, innovation, or inventiveness?<br>2. What specific classroom activities, teaching strategies, or learning tasks do you experience that promote scientific inquiry and problem-solving?<br>3. In what ways does your institution or department support activities (e.g., projects, laboratories, competitions) that encourage innovative thinking in science? |
| To describe the experiences and perspectives of learners regarding the development of creativity, innovation, and inventive thinking in science learning environments. | 1. How do you personally experience learning science in a way that develops your creativity and ability to think innovatively?<br>2. Can you describe situations in your science classes where you were encouraged to think critically, solve problems, or create new ideas or solutions?<br>3. In your view, what factors (e.g., teaching methods, classroom environment, peers, or resources) most influence your ability to develop inventive thinking in science? |

*Note: Follow-up questions and probing techniques may be used during the interview to clarify responses, deepen discussion, and explore emerging ideas that are relevant to the research objectives. The guide is not intended to restrict participants' responses but to serve as a framework for ensuring that key areas of inquiry are adequately covered.*

***Data Gathering Procedure***

Data collection was conducted in a systematic and ethically rigorous manner to uphold the integrity of the qualitative research process. Participants were formally contacted and invited to take part in the study. Prior to the conduct of interviews, informed consent was obtained, with participants being clearly informed of the voluntary nature of their participation as well as the strict measures implemented to ensure confidentiality and anonymity.

The interviews were conducted either via telephone calls or through Messenger, depending on the participants' availability and preferred mode of communication. These platforms were selected to address geographical limitations and to facilitate convenient participation for respondents located in regional areas. Each interview session lasted approximately 45 to 60 minutes, allowing for a comprehensive and in-depth exploration of participants' experiences and perspectives.

With the consent of the participants, all interviews were audio-recorded to ensure accurate transcription and facilitate rigorous data analysis. Furthermore, field notes were taken throughout the data collection process to capture contextual observations, participant responses, and other relevant non-verbal or narrative details that contributed to the richness of the data.

***Data Analysis***

The primary data for this study consisted of narrative accounts provided by college students. A reflexive thematic analysis approach was employed to systematically interpret and derive meaning from the participants' experiences and perspectives (Braun & Clarke, 2019).

All interview recordings were transcribed verbatim to ensure the preservation of the authenticity, accuracy, and richness of the participants' original responses. The analysis started with repeated and immersive reading of the transcripts to facilitate familiarization with the data and to establish a comprehensive understanding of its content.

Initial coding was undertaken to identify significant and meaningful segments of information within the dataset. These codes were subsequently organized into broader categories that reflect recurring patterns across participants' accounts. These categories were further refined and developed into broader themes that illuminate relationships, contextual influences, and institutional dynamics within science learning environments.

Reflexivity was consistently practiced minimizing potential researcher bias and to enhance the credibility, trustworthiness, and interpretive rigor of the findings (Españo et al., 2025).

**Results**

Objective 1. To explore the practices and strategies employed by higher education institutions in cultivating a culture of inventiveness within science education.

Question 1. How do your science teachers design or conduct lessons that encourage creativity, innovation, or inventiveness?

Theme 1: Inquiry-Driven and Problem-Based Instruction

Students describe that science teachers design lessons around inquiry-based and problem-solving activities that require them to investigate real-world issues, formulate hypotheses, and develop evidence-based solutions. This instructional approach encourages active exploration rather than passive learning, fostering creative and innovative thinking.

> "Pinapagawa kami ng teachers namin ng mga activities na kailangang mag-isip talaga, hindi yung basta sumagot lang." Translation: Our teachers give us activities that really require thinking, not just simple answering.
> "May mga tanong sila na kailangan naming i-research at hanapan ng solusyon sa totoong buhay."
> Translation: They give questions that we need to research and find real-life solutions for.
> "Hindi lang puro lecture, pinapagawa rin kami ng mga problem-solving tasks. Like sa agriculture subject, pinapaisip kami paano aayusin yung soil problem sa isang farm sa barangay." Translation: It's not just lectures; we are also given problem-solving tasks. In agriculture, we are asked how to solve a soil problem in a farm in the barangay.

Theme 2: Experiential Learning Opportunities

Participants highlight the use of laboratory work, experiments, simulations, and project-based tasks as key strategies used by teachers. These hands-on learning experiences allow students to apply theoretical concepts in practical contexts, thereby enhancing their ability to generate ideas and engage in inventive processes.

> "Mas nagiging interesting yung lessons kasi may hands-on activities talaga. Sa biology, nagdi-dissect kami ng specimens para makita mismo yung parts ng organism." Translation: Lessons become more interesting because there are really hands-on activities. In biology, we dissect specimens to actually see the parts of an organism.
> "Mas naaalala namin yung lesson kapag kami mismo yung gumagawa ng project. Sa science, gumagawa kami ng model ng ecosystem gamit recycled materials." Translation: We remember the lesson better when we are the ones doing the project. In science, we make an ecosystem model using recycled materials.
> "We enjoy learning more because it's not just lectures, we actually do things. In agriculture, we take care of plants in the school garden and observe their growth."

Theme 3: Flexible Teaching for Student Autonomy

Students report that teachers employ flexible and student-centered strategies such as open-ended tasks, collaborative group work, and freedom in choosing project outputs. This autonomy in learning encourages students to explore different solutions, think independently, and express creativity in diverse ways.

> "Teachers give us open-ended tasks so we can think of our own solutions."
> "May group activities kami na kami-kami rin ang nagdi-decide kung paano namin gagawin yung output. Sa biology, kami yung nagplano kung paano namin ipapresent yung report." Translation: We have group activities where we also decide how we will do the output. In biology, we were the ones who planned how we would present our report.

Question 2. What specific classroom activities, teaching strategies, or learning tasks do you experience that promote scientific inquiry and problem-solving?

Theme 1: Guided Experimentation with Partial Instruction

Participants describe learning tasks where teachers provide only limited procedures or outcomes, requiring students to independently determine steps, methods, or interpretations during experiments. This guided yet incomplete structure encourages investigation, hypothesis testing, and critical thinking throughout the learning process.

> "Sometimes the teacher doesn't give the full steps, we are the ones who figure out how to do the experiment. We were just given materials, then we had to think of the procedure ourselves."

"May mga experiment na parang kulang yung instructions kaya kailangan namin mag-isip at mag-try-try ng methods." Translation: There are experiments where the instructions are incomplete, so we need to think and try different methods.

"Hindi laging sinasabi ng teacher yung expected result kaya kami nag-huhypothesize muna bago gawin yung experiment." Translation: The teacher doesn't always tell the expected result, so we hypothesize first before doing the experiment.

Theme 2: Collaborative Scientific Reasoning Activities

Students engage in structured group-based tasks where they collectively analyze data, debate explanations, and defend scientific conclusions. These collaborative activities promote shared inquiry, peer questioning, and collective problem-solving, allowing students to refine their understanding through discussion and evidence-based reasoning.

"Mas okay kasi pag group work, sabay-sabay kami nag-a-analyze ng data para mahanap yung tamang sagot. Sa physics, pinaghahati-hati namin yung data ng experiment tapos pinag-uusapan namin yung result." Translation: It's better because in group work, we analyze data together to find the correct answer. In physics, we divide the experiment data and then discuss the results.

"Kailangan naming i-explain at i-defend yung answer namin sa group sa harap ng class. Pinapaliwanag namin kung bakit ganun yung naging reaction." Translation: We need to explain and defend our group answer in front of the class. We explain why the reaction happened that way.

Question 3. In what ways does your institution or department support activities (e.g., projects, laboratories, competitions) that encourage innovative thinking in science?

Theme 1: Innovation Showcases

Students experience institutional encouragement through organized science fairs, exhibitions, and innovation days where they are given opportunities to present inventions, models, and research outputs. These events serve as platforms for showcasing creativity and motivate students to develop innovative scientific outputs beyond classroom requirements.

"May mga exhibition activities kung saan pinapakita namin yung mga output namin sa ibang students at teachers. Nag-display kami ng simple experiment setup sa booth namin." Translation: There are exhibition activities where we show our outputs to other students and teachers. In chemistry, we displayed a simple experiment setup in our booth.

"We also have innovation day where we present creative ideas or inventions. We presented an idea on how to recycle plastic waste into useful materials."

"We are more encouraged to improve our project because we know it will be shown in the science fair."

Theme 2: Access to Laboratory Facilities and Learning Resources

Participants highlight that the institution supports innovation by providing access to laboratories, equipment, and learning materials needed for experimentation and project development. This resource support enables students to conduct scientific investigations, test ideas, and engage in practical exploration that enhances inventive thinking.

"May mga equipment na pinapagamit sa amin kaya nagagawa namin yung mga experiments kahit complicated." Translation: We are allowed to use equipment so we can do experiments even if they are complicated.

> "Complete yung materials sa lab kaya hindi kami nahihirapan mag-test ng ideas." Translation: The lab has complete materials so we don't have a hard time testing ideas.
> "Mas madali gumawa ng project kasi may available na resources sa school. Gumamit kami ng recycled materials at lab tools para sa project namin." Translation: It's easier to make projects because resources are available in school. We used recycled materials and lab tools for our project.

Theme 3: Academic Guidance for Research

Students describe the presence of teacher mentorship and departmental guidance in developing scientific projects and research outputs. Faculty members provide advice, feedback, and supervision that help students improve their ideas, improve methodologies, and strengthen the quality of their innovative outputs.

> "Tinutulungan talaga kami ng teachers kapag may research or project kami, may mga suggestions sila kung paano pa mapapaganda." Sa science, in-adjust namin yung topic namin kasi nirecommend ng teacher na mas feasible siya." Translation: Teachers really help us when we have research or projects, they give suggestions on how to improve them. For example, we changed our topic because the teacher recommended a more feasible one.
> "When we have projects, we are always given feedback on what still needs improvement."
> "Mas gumaganda yung output namin kasi ina-guide kami ng teachers step-by-step. Tinulungan kami ng instructor kung paano gumawa ng proper research tungkol sa plants and soil." Translation: Our output gets better because teachers guide us step-by-step. Our instructor helped us how to properly conduct research on plants and soil.

Objective 2. To describe the experiences and perspectives of learners regarding the development of creativity, innovation, and inventive thinking in science learning environments.
Question 1. How do you personally experience learning science in a way that develops your creativity and ability to think innovatively?
Theme 1: Creativity Development

Students describe that their creativity is developed when science lessons involve problem-based tasks that require them to generate multiple solutions, analyze situations, and think beyond memorized concepts. These experiences push learners to construct their own ideas rather than rely on fixed answers, strengthening their innovative thinking.

> "Mas nagiging creative ako sa science kapag may mga problem na kailangan naming solusyunan in different ways." Translation: I become more creative in science when we are given problems that we need to solve in different ways.
> "Hindi lang siya puro memorization, kailangan talaga mag-isip ng sariling idea." Translation: It's not just memorization, we really need to think of our own ideas.
> "I am more encouraged to think of different solutions when there are open-ended questions."

Theme 2: Discovery of Innovation

Participants experience creativity growth through hands-on experiments, exploration, and trial-and-error activities in science classes. These learning experiences allow students to discover scientific concepts independently, make observations, and refine ideas through experimentation, which enhances their capacity for innovation.

> "Mas natututo ako ng science kapag kami mismo yung nag-eexperiment sa lab at nakikita yung resulta." For example, kami yung nagmi-mix ng substances para makita kung anong reaction mangyayari." Translation: I learn science better when we are the ones doing

experiments in the lab and seeing the results. For example, we mix substances ourselves to see what reaction will happen."

"Mas na-eenjoy ko yung learning kasi pwede kaming mag-try ng iba't ibang ways hanggang gumana yung experiment." Translation: I enjoy learning more because we can try different ways until the experiment works.

"I become more curious because we have the chance to explore and test ideas. We observe how plants grow under different conditions."

Theme 3: Cognitive Growth

Students report that their innovative thinking develops through reflective activities such as explaining concepts, justifying answers, and connecting lessons to real-life contexts. These reflective processes enable learners to make sense of scientific knowledge, evaluate their understanding, and develop deeper creative insights.

"I think more deeply when I need to justify my answer."

"Mas nagiging clear sa isip ko yung lesson kapag inuugnay namin siya sa real-life situations." Translation: The lesson becomes clearer in my mind when we connect it to real-life situations.

"Mas natututo ako kasi pinapaisip talaga kami kung bakit ganun yung nangyari." Translation: I learn more because we are really made to think why something happened.

"My creativity develops because we are always asked to reflect on our answers."

Question 2. Can you describe situations in your science classes where you were encouraged to think critically, solve problems, or create new ideas or solutions?

Theme 1: Open-Ended Scientific Tasks

Participants experience encouragement to think critically through activities that do not have fixed answers. Open-ended questions, exploratory tasks, and flexible problem-solving exercises push students to generate their own explanations, test ideas, and develop original solutions.

"Minsan open-ended yung questions kaya kami na bahala mag-explain at magbigay ng idea." Translation: Sometimes the questions are open-ended so we are the ones who explain and give ideas.

"Mas napipilitan kaming mag-isip kasi hindi laging may step-by-step na guide." Translation: We are forced to think more because there is not always a step-by-step guide.

"Mas na-eencourage kami mag-try ng different ideas hanggang makahanap ng solution." Translation: We are encouraged to try different ideas until we find a solution.

Theme 2: Scientific Discussion

Students report being placed in group situations where they are encouraged to share ideas, debate possible answers, and collectively construct solutions. Through peer interaction and discussion, learners refine their thinking, evaluate alternative perspectives, and develop more innovative scientific ideas.

"May mga times na nag-aargue kami ng classmates kung alin yung mas tamang explanation." Translation: There are times we argue with classmates about which explanation is more correct.

"We learn more because there is really an exchange of ideas in group discussion."

"Mas na-iimprove yung thinking namin kasi pinapakinggan namin yung ideas ng bawat isa." Translation: Our thinking improves because we listen to each other's ideas.

> "Mas nagiging confident kami mag-explain kasi lagi kaming nagdi-discuss sa group." Translation: We become more confident in explaining because we always discuss in groups.

Question 3. In your view, what factors (e.g., teaching methods, classroom environment, peers, or resources) most influence your ability to develop inventive thinking in science?

Theme 1: Teacher Facilitation

Students emphasize that the way teachers deliver lessons strongly shapes their ability to think inventively. Flexible teaching approaches, questioning techniques, and the use of challenging tasks encourage learners to think beyond memorized content and explore original scientific ideas.

> "Malaking factor talaga yung teaching style ng teacher kasi doon kami na-eencourage mag-isip ng iba't ibang idea." Translation: The teacher's teaching style is a big factor because it encourages us to think of different ideas.
>
> "Yung mga challenging tasks ng teacher nakakatulong talaga para mag-isip kami deeper…binibigyan kami ng problem na kailangan naming i-solve in different ways." Translation: The teacher's challenging tasks really help us think deeper…we are given problems that we need to solve in different ways.
>
> "We are more encouraged to innovate when the discussion is not spoon-feeding."

Theme 2: Peer Interaction

Participants highlight that classmates and group interactions significantly influence inventive thinking. Through sharing ideas, debating solutions, and learning from peers, students are exposed to diverse perspectives that help refine their thinking and generate more creative scientific outputs.

> "Mas natututo kami kasi nakakarinig kami ng iba't ibang ideas galing sa classmates." Translation: We learn more because we hear different ideas from classmates.
>
> "Mas nagiging confident kami mag-explain kasi lagi kaming nagdi-discuss sa group." Translation: We become more confident in explaining because we always discuss in groups.
>
> "Our ideas become better when we talk with classmates in a group..."

Theme 3: Availability of Learning Environment

Students describe that access to supportive learning environments, such as laboratories, equipment, and instructional materials, plays a crucial role in developing inventive thinking. Adequate resources allow learners to test ideas, conduct experiments, and transform abstract concepts into practical scientific understanding.

> "We can think of more ideas because we have complete lab equipment that we can use. We can test reactions using real materials in the lab."
>
> "We become more creative because we have a proper classroom and lab where we can do experiments."
>
> "It's easier to explore ideas because materials are already available in school."
>
> "Mas nagiging interesting yung learning kasi may resources talaga na pang-experiment. May garden kami sa school kung saan pwede kami makatanim." Translation: Learning becomes more interesting because we really have resources for experiments. We have a school garden where we can plant.

**Discussion**

Competent science students are essential in modern-day industries because they serve as future contributors to scientific advancement, technological innovation, and evidence-based problem-solving.

Their knowledge, creativity, and ability to apply scientific concepts enable them to respond to complex challenges in fields such as healthcare, agriculture, environmental management, engineering, and emerging technologies. This study noted that effective science education in higher education is driven by a culture that uplifts the concept of educating students *from curiosity to creation*.

In this study, an effective culture is composed of a learning environment that promotes *curiosity*, *creativity*, *experimentation*, *collaboration*, and *independent thinking* among science learners. It involves instructional practices that encourage students to explore ideas, investigate problems, develop solutions, and apply scientific knowledge in meaningful contexts. Specifically, it is shaped by inquiry-driven instruction, experiential learning opportunities, flexible teaching approaches, supportive peer interactions, adequate learning resources, and academic guidance that enable students to transform scientific concepts into innovative outputs.

Hofstede (2011) describes culture as a form of "shared mental programming" that influences the way individuals within a group perceive, think, and behave, thereby distinguishing one group from another. To enhance science education, there is a need for a culture that supports curiosity, creativity, collaboration, inquiry, and innovation among learners. Such a culture encourages students to actively engage in scientific exploration, develop critical thinking skills, and apply knowledge in solving real-world problems. Cultivating this type of culture requires learning environments where students are encouraged to question, experiment, exchange ideas, and transform scientific concepts into meaningful and innovative solutions.

For example, a meaningful scientific culture allows students to share their perspectives, engage in critical questioning, and actively contribute to discussions and decision-making processes (Kole, 2025). This culture increases students' confidence in themselves, strengthens their sense of academic agency, and encourages them to view scientific knowledge as something that is constructed. As students are consistently exposed to dialogic and inquiry-driven learning environments, they develop greater willingness to articulate ideas, defend their reasoning, and adapt their understanding through feedback and peer interaction.

Of course, an effective science culture requires support from teachers and school administrators. Teachers may implement open-ended tasks, collaborative learning strategies, and inquiry-based approaches that promote creativity, innovation, and adaptability among learners (Adeoye et al., 2024). One notable instance of this is guided experimentation with partial instruction. Partial instruction in this context means providing learners with essential concepts, safety guidelines, and key procedures, while deliberately leaving room for students to design parts of the investigation, make predictions, and determine certain methodological choices. This approach positions students within a semi-structured learning environment where cognitive scaffolding is present, but autonomy is also intentionally cultivated.

Furthermore, it is essential to reconceptualize culture not as a stable or fixed set of traits, but as a dynamic and continuously evolving process shaped by shifting beliefs, values, behaviors, and lived experiences (Xing & Jin, 2023). In this study, constructive feedback, peer discussions, and collaborative reflection serve as key mechanisms through which this evolving culture is enacted and sustained within the learning environment. These practices create opportunities for learners to continuously develop their understanding of science concepts, challenge existing assumptions, and reconstruct knowledge through social interaction and guided dialogue. These aspects are essential in building students' ability to solve social problems that interest them.

At a broader scale, a culture should be able to respond to the needs of students, much like how student-centered curriculum responds to multi-dimensional classrooms. Student-centered learning is supported by several interrelated theoretical frameworks that collectively explain how culture and science learning are shaped through interaction, cognition, and experience.

In student-centered learning, constructivism emphasizes that learners actively build knowledge by integrating new information with prior understanding (Chen & Tsai, 2021), highlighting the importance of inquiry-based, hands-on, and exploratory science learning environments where students construct meaning from scientific concepts. Social constructivism extends this by situating learning within a cultural and social context, arguing that knowledge is co-constructed through interaction with peers, teachers, and the wider community, emphasizing collaboration, communication, and shared scientific meaning-making (Shehata et al., 2023). Cognitive psychology further contributes by focusing on internal mental processes such as thinking, memory, attention, and problem-solving, which are essential in developing scientific reasoning and applying concepts in complex situations (Mat & Jamaludin, 2024).

**Conclusion**

A meaningful science culture in education should be able to harness students' curiosity and transform it into purposeful scientific creation. The study noted that effective science education in higher education is anchored on a culture that nurtures curiosity, creativity, experimentation, collaboration, critical thinking, and independent inquiry, allowing students to actively engage in exploring ideas, investigating problems, and applying scientific knowledge in meaningful and real-world contexts.

In science education, shared mental programming should intentionally promote inquiry, collaboration, and innovation so that learners are encouraged to question, experiment, exchange ideas, and translate concepts into solutions. A meaningful scientific culture allows students to share perspectives, engage in critical questioning, and participate in decision-making processes, which then helps in strengthening their confidence, academic agency, and understanding of science as a constructed body of knowledge. Finally, strategies such as open-ended tasks, collaborative learning, inquiry-based instruction, and experiential learning promote creativity, innovation, and adaptability among learners

**Recommendations**

The study revealed some promising results, which yielded important implications for strengthening science education and cultivating an effective science learning culture in higher education.

First, higher education institutions should institutionalize student-centered and inquiry-driven pedagogies by integrating them consistently across science courses. This includes expanding the use of open-ended tasks, problem-based learning, and guided experimentation to continuously develop students' curiosity, creativity, and scientific reasoning.

Second, teachers are encouraged to strengthen the use of formative assessment practices such as constructive feedback, peer assessment, and reflective learning activities. These approaches help sustain an evolving science culture by allowing students to continuously improve their understanding, correct misconceptions, and develop deeper conceptual mastery through social interaction and guided dialogue.

Third, academic administrators should provide sustained support through adequate laboratory facilities, learning resources, and professional development programs for teachers. Training programs may focus on innovative instructional design, facilitation of inquiry-based learning, and integration of collaborative learning strategies to ensure that educators are well-equipped to implement student-centered science education effectively.

Fourth, the curriculum designers should emphasize the integration of real-world applications and interdisciplinary connections in science instruction. Linking scientific concepts to societal issues such as environmental sustainability, public health, and technological innovation can strengthen students' motivation and help them see the relevance of science in addressing authentic problems.

Finally, future initiatives should promote a flexible and adaptive science learning culture that recognizes culture as dynamic and continuously evolving.

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