

International Journal of Technology, AI and STEM Education

<https://ijtase.minduraresearch.com/journal/index>

ISSN (ONLINE): 3116-3718

Volume 1 Issue 3 - 2026

Inquiry-Based Science Teaching and Learners' Academic Engagement at Rufino I. Chungalao Science High School

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Date Submitted:

March 5, 2026

Date Accepted:

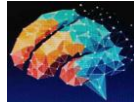
May 15, 2026

Date Published:

June 30, 2026

ABSTRACT: Inquiry-based science teaching has been widely promoted as an instructional approach that fosters active learning, critical thinking, and sustained learner engagement. In science high schools, where learners are expected to demonstrate higher-order thinking and scientific reasoning, inquiry-based instruction is particularly relevant. However, empirical studies examining how inquiry-based science teaching shapes learners' academic engagement especially within Philippine public science high school contexts remain limited. This qualitative case study investigated how inquiry-based science teaching was implemented at Rufino I. Chungalao Science High School and how it influenced learners' behavioral, emotional, and cognitive engagement. Data were collected through classroom observations, focus group discussions with learners, and semi-structured interviews with science teachers. Thematic analysis revealed four major findings: (1) inquiry tasks promoted active behavioral participation, (2) learner autonomy and curiosity enhanced emotional engagement, (3) collaborative investigation sustained engagement and sense-making, and (4) teacher scaffolding supported deep cognitive engagement. While learners reported heightened interest and ownership of learning, challenges related to time constraints and varying learner readiness were also identified. The study concludes that inquiry-based science teaching meaningfully enhances academic engagement when supported by structured guidance and reflective practice. Implications for science instruction, school leadership, and future research are discussed.

Keywords: inquiry-based learning; science education; academic engagement; qualitative case study; secondary education



1. Introduction

Academic engagement is a critical determinant of learners' success in science education, influencing not only achievement but also motivation, persistence, and interest in scientific inquiry. Engaged learners are more likely to participate actively, invest effort in complex problem-solving, and develop positive dispositions toward learning science. In contrast, disengagement in science classrooms often manifests as passive participation, surface learning, and declining interest, particularly when instruction relies heavily on lecture-based approaches.

Inquiry-based science teaching has emerged as a response to these challenges, emphasizing learning through questioning, investigation, experimentation, and evidence-based reasoning. Rooted in constructivist learning theory, inquiry-based instruction positions learners as active constructors of knowledge rather than passive recipients of information. In science high schools, where learners are expected to demonstrate scientific literacy and analytical thinking, inquiry-based teaching aligns closely with curricular goals and learner expectations.

Despite strong theoretical and policy support for inquiry-based learning, its classroom enactment varies widely, and its influence on learners' academic engagement is shaped by contextual factors such as teacher practices, learner readiness, and instructional support. In the Philippine context, particularly in public science high schools, empirical research examining how inquiry-based science teaching affects learners' engagement across behavioral, emotional, and cognitive dimensions remains limited. This study addresses this gap by examining inquiry-based science teaching and learners' academic engagement at Rufino I. Chungalao Science High School.

Research Questions

1. How is inquiry-based science teaching implemented in classrooms at Rufino I. Chungalao Science High School?
2. How do learners experience inquiry-based science instruction?
3. In what ways does inquiry-based teaching influence learners' behavioral, emotional, and cognitive engagement?

2. Review of Related Literature

Inquiry-based learning is grounded in constructivist and sociocultural theories that emphasize learning as an active process of meaning-making through interaction, exploration, and reflection (Vygotsky, 1978). In science education, inquiry-based instruction encourages learners to pose questions, design investigations, analyze data, and construct explanations based on evidence (National Research Council, 2000). Research indicates that inquiry-based approaches enhance conceptual understanding and scientific reasoning when learners are provided with appropriate guidance and structure (Hmelo-Silver, Duncan, & Chinn, 2007).

Academic engagement is commonly conceptualized as a multidimensional construct encompassing behavioral participation, emotional involvement, and cognitive investment in learning tasks



International Journal of Technology, AI and STEM Education

<https://ijtase.minduraresearch.com/journal/index>

ISSN (ONLINE): 3116-3718

Volume 1 Issue 3 - 2026

(Fredricks, Blumenfeld, & Paris, 2004). Studies have shown that instructional practices promoting autonomy, relevance and interaction core features of inquiry-based learning are strongly associated with higher levels of engagement in science classrooms (Skinner, Kindermann, & Furrer, 2009).

However, research also cautions that inquiry-based learning is not inherently engaging without careful instructional design. Learners may experience frustration or disengagement when inquiry tasks are poorly structured or exceed their readiness levels (Kirschner, Sweller, & Clark, 2006). Thus, teacher scaffolding and reflective facilitation are critical to sustaining engagement and learning.

3. Methodology

This study employed a qualitative case study design to explore inquiry-based science teaching and learners' academic engagement within a real-life secondary school context. The case study approach was selected to allow for an in-depth examination of instructional practices and learner experiences as they naturally occurred in science classrooms. The study was conducted at Rufino I. Chungalao Science High School, a public science high school serving academically selected learners from diverse socioeconomic backgrounds.

Participants included six science teachers implementing inquiry-based instructional strategies and twenty-seven learners from Grades 9 and 10 selected through purposive sampling to represent varied engagement levels and academic performance. Data were collected over one academic term using multiple qualitative methods. Classroom observations documented inquiry activities, teacher facilitation, and learner participation. Focus group discussions with learners explored perceptions of inquiry tasks, motivation, and engagement. Semi-structured interviews with teachers examined instructional intentions, inquiry design, and perceived challenges. All data were transcribed verbatim and analyzed using thematic analysis following Braun and Clarke's (2006) six-phase framework. Trustworthiness was ensured through triangulation, peer debriefing, and member checking. Ethical approval was obtained, informed consent and learner assent were secured, and pseudonyms were used to maintain confidentiality.

4. Results and Findings

Theme 1: Inquiry Tasks as Catalysts for Behavioral Engagement

Classroom observations revealed that inquiry-based tasks such as laboratory investigations, hypothesis formulation, data collection, and evidence-based analysis functioned as strong catalysts for behavioral engagement. During inquiry lessons, learners were actively involved in manipulating laboratory materials, recording observations, discussing procedures, and revising experimental designs. Compared with more teacher-directed lessons, inquiry sessions were marked by higher levels of sustained on-task behavior, frequent learner-initiated questions, and visible attentiveness throughout extended periods of investigation. Learners assumed responsibility for procedural steps, which positioned participation as a requirement rather than an option, thereby normalizing active involvement as part of science learning.

Learners explicitly recognized the impact of inquiry on their participation. One learner shared, "*Mas aktibo kami kapag kami ang nag-e-experiment,*" indicating that hands-on investigation compelled engagement and reduced passive behavior. However, several learners acknowledged initial difficulty adjusting to open-ended tasks, noting uncertainty about what to do first or how to proceed without

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explicit instructions. This suggests that while inquiry tasks strongly promote behavioral engagement, learners may require time and support to adapt to less structured learning environments. Hence, the findings indicate that inquiry tasks enhance behavioral engagement by demanding active participation and responsibility, consistent with research highlighting inquiry as a means of shifting learners from passive listening to active scientific practice (National Research Council, 2000).

Theme 2: Curiosity and Autonomy Strengthened Emotional Engagement

Inquiry-based instruction fostered emotional engagement by stimulating curiosity, interest, and enjoyment as learners explored scientific questions and phenomena. Opportunities to generate questions, design investigations, and test hypotheses allowed learners to experience science as a process of discovery rather than memorization. Observations showed learners expressing excitement when experiments yielded unexpected results and enthusiasm when discussing interpretations with peers. This sense of exploration contributed to positive emotional responses toward science learning.

Learners articulated this emotional shift clearly. One learner stated, *"Mas nae-enjoy ko ang science kapag kami ang nag-iisip ng sagot,"* reflecting how autonomy enhanced enjoyment and motivation. However, not all learners experienced inquiry positively at all times. Some expressed anxiety when tasks lacked clear direction, particularly during initial stages of inquiry, as they feared making mistakes or pursuing incorrect approaches. These mixed responses suggest that emotional engagement through inquiry is closely tied to learners' perceptions of autonomy and competence. The findings align with self-determination theory, which posits that autonomy enhances emotional engagement when learners feel both choice and adequate support (Deci & Ryan, 2000). When autonomy was accompanied by guidance, learners' curiosity translated into sustained emotional investment.

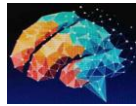
Theme 3: Collaborative Investigation Sustained Engagement

Collaborative investigation emerged as a key structure for sustaining engagement throughout inquiry activities. Group-based inquiry encouraged peer interaction, discussion, and shared problem-solving, allowing learners to articulate ideas, challenge assumptions, and co-construct explanations. Observations revealed that learners remained engaged for longer periods when working collaboratively, as dialogue helped maintain focus and momentum during complex tasks. Peer interaction also served as a source of clarification and reassurance, particularly when learners encountered difficulties.

Learners consistently valued collaborative inquiry. One learner shared, *"Mas naiintindihan ko kapag pinapaliwanag ng kaklase ko,"* emphasizing the role of peer explanations in understanding scientific concepts. At the same time, uneven participation within groups was occasionally observed, with some learners assuming dominant roles while others remained passive. Teachers addressed this challenge by assigning roles and monitoring group dynamics. These findings support research on cooperative learning, which highlights collaboration as a mechanism for sustaining engagement while underscoring the need for structured group processes to ensure equitable participation (Johnson & Johnson, 2009).

Theme 4: Teacher Scaffolding Supported Cognitive Engagement

Teacher scaffolding played a critical role in supporting cognitive engagement during inquiry-based instruction. Teachers guided inquiry through strategic questioning, modeling of scientific reasoning,



and formative feedback that prompted learners to reflect on evidence and refine explanations. Rather than providing direct answers, teachers used probing questions to help learners connect observations to underlying concepts and evaluate the validity of their conclusions. This approach encouraged learners to engage in higher-order thinking, such as analysis, interpretation, and justification.

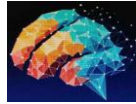
Teachers emphasized the importance of guidance, with one noting, "*Kailangan gabayan ang tanong ng bata,*" highlighting the role of facilitation in productive inquiry. Learners reported deeper understanding when teachers provided timely prompts and feedback, particularly during data interpretation and conclusion-drawing stages. Without scaffolding, some learners struggled to make sense of complex data, leading to frustration. These findings align with research emphasizing that guided inquiry rather than minimally guided discovery is essential for supporting cognitive engagement and conceptual understanding in science learning (Hmelo-Silver, Duncan, & Chinn, 2007).

5. Discussion

The findings of this study demonstrate that inquiry-based science teaching enhances academic engagement by activating the interrelated behavioral, emotional, and cognitive dimensions of learning. Behavioral engagement was most evident when learners were immersed in inquiry tasks that required hands-on investigation, data collection, experimentation, and discussion. These tasks positioned learners as active participants in the learning process rather than passive recipients of information, leading to sustained on-task behavior and increased classroom participation. Emotional engagement was strengthened through learner autonomy inherent in inquiry-based instruction, as opportunities to ask questions, design investigations, and explore scientific phenomena fostered curiosity, enjoyment, and a sense of ownership over learning. Collaborative inquiry further sustained engagement by enabling learners to exchange ideas, negotiate meanings, and support one another in solving complex scientific problems, reinforcing the social nature of learning. Cognitive engagement emerged through structured scaffolding provided by teachers, including probing questions, modeling of scientific reasoning, and formative feedback, which guided learners to analyze evidence, reflect on their thinking, and construct deeper conceptual understanding.

Collectively, these patterns align closely with Fredricks, Blumenfeld, and Paris's (2004) multidimensional engagement framework, which conceptualizes engagement as the dynamic interaction of behavioral participation, emotional involvement, and cognitive investment. The findings extend this framework within science high school contexts by illustrating how inquiry-based pedagogy operationalizes each dimension of engagement through specific instructional practices. Rather than functioning independently, these dimensions reinforced one another; emotional investment generated by curiosity and autonomy often encouraged behavioral participation, while cognitive engagement supported learners' persistence and willingness to engage in inquiry activities. This interconnectedness underscores the value of inquiry-based instruction as a holistic approach to fostering engagement in science education.

At the same time, the study highlights important challenges that shape the effectiveness of inquiry-based teaching. Time constraints associated with completing investigations and facilitating reflective discussion sometimes limited opportunities for deeper exploration, while variations in learner readiness influenced how learners responded to open-ended inquiry tasks. These challenges underscore the importance of structured inquiry and sustained teacher support in maintaining



International Journal of Technology, AI and STEM Education

<https://ijtase.minduraresearch.com/journal/index>

ISSN (ONLINE): 3116-3718

Volume 1 Issue 3 - 2026

engagement. Inquiry-based teaching is most effective when openness is balanced with clear expectations, guided questioning, and appropriate scaffolding that supports learners at different readiness levels. Without such balance, inquiry may lead to confusion or disengagement rather than deeper learning. The findings thus reinforce the need for intentional instructional design and teacher facilitation to ensure that inquiry-based science teaching fulfills its potential to enhance academic engagement.

Cross-Theme Discussion

The cross-theme analysis reveals that inquiry-based science teaching functions as a coherent pedagogical system that activates learners' academic engagement through the dynamic interaction of inquiry tasks, learner autonomy, collaborative investigation, and teacher scaffolding. Rather than operating as isolated instructional elements, these components worked synergistically to shape learners' behavioral, emotional, and cognitive engagement in science classrooms. Inquiry tasks served as the structural backbone of instruction, compelling learners to participate actively through experimentation, observation, and evidence-based reasoning. This active participation normalized engagement as an expected aspect of learning science, thereby strengthening behavioral engagement and reducing passive classroom behaviors.

Learner autonomy, embedded within inquiry-based instruction, emerged as a powerful driver of emotional engagement. Opportunities to pose questions, make decisions about investigative procedures, and interpret findings fostered curiosity, enjoyment, and a sense of ownership over learning. These emotional responses were not merely affective outcomes but played a functional role in sustaining learners' willingness to participate and persist in complex tasks. However, the findings also indicate that autonomy alone was insufficient to sustain engagement; when inquiry lacked clear direction, learners experienced uncertainty and anxiety. This highlights the importance of coupling autonomy with appropriate instructional structure to support learners' sense of competence.

Collaborative investigation further reinforced engagement by situating learning within social interaction. Peer dialogue, shared problem-solving, and collective sense-making enabled learners to clarify ideas, negotiate meanings, and sustain attention during extended inquiry tasks. Collaboration functioned as a stabilizing force, particularly when individual learners encountered conceptual difficulties. At the same time, challenges related to uneven participation underscored the need for intentional group structures and role assignment. These findings suggest that collaboration enhances engagement most effectively when it is deliberately designed and actively facilitated by the teacher.

Teacher scaffolding emerged as the critical integrative mechanism across all themes, linking inquiry tasks, autonomy, and collaboration into a productive learning experience. Through strategic questioning, modeling, and formative feedback, teachers guided learners' thinking without undermining the exploratory nature of inquiry. Scaffolding supported cognitive engagement by helping learners connect empirical evidence to scientific concepts, reflect on their reasoning, and refine explanations. Importantly, scaffolding also mediated the emotional and behavioral dimensions of engagement by reducing frustration, clarifying expectations, and sustaining learners' confidence during challenging tasks.

Collectively, these cross-theme patterns align with and extend Fredricks, Blumenfeld, and Paris's (2004) multidimensional engagement framework within a science high school context. The findings

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illustrate that inquiry-based science teaching operationalizes behavioral, emotional, and cognitive engagement through specific, interrelated pedagogical practices. Engagement emerged not from inquiry alone but from a balanced instructional design in which openness was carefully calibrated with guidance, and learner agency was supported by social interaction and teacher facilitation. This synthesis underscores that inquiry-based science teaching is most effective as an engagement-oriented pedagogy when implemented as an integrated system rather than as a set of discrete strategies.

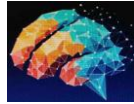
At a broader level, the cross-theme discussion highlights the importance of instructional intentionality in inquiry-based science education. While inquiry holds strong potential to enhance engagement, its success depends on teachers' capacity to design structured inquiry tasks, scaffold learning appropriately, and manage collaborative dynamics. These findings reinforce the view that inquiry-based teaching is a sophisticated pedagogical approach that requires sustained professional development and reflective practice. When thoughtfully enacted, inquiry-based science teaching can serve as a powerful means of fostering deep, sustained academic engagement and cultivating learners' identities as active participants in scientific inquiry.

6. Conclusions and Implications

This study provides compelling evidence that inquiry-based science teaching meaningfully enhances learners' academic engagement at Rufino I. Chungalao Science High School by activating learners' behavioral, emotional, and cognitive involvement in the learning process. The findings show that when inquiry-based instruction is thoughtfully designed and appropriately supported, it moves learners beyond passive reception of scientific knowledge toward active participation in questioning, investigating, and reasoning. Inquiry tasks encouraged sustained behavioral engagement as learners manipulated materials, analyzed data, and participated in scientific discussions. At the same time, opportunities for exploration and decision-making nurtured curiosity and intrinsic motivation, strengthening learners' emotional engagement. Collaborative inquiry further supported shared sense-making and persistence, while teacher scaffolding enabled learners to connect evidence with scientific concepts, thereby deepening cognitive engagement and conceptual understanding.

The study also highlights important implications for classroom practice. Science teachers are encouraged to design structured inquiry tasks that balance openness with clear guidance, ensuring that learners are challenged without being overwhelmed. The strategic use of formative scaffolding through questioning, modeling, and timely feedback can support learners' thinking processes and help sustain engagement across different stages of inquiry. Differentiating inquiry tasks based on learners' readiness levels may further enhance participation and understanding, particularly in academically diverse classrooms.

At the level of school leadership, the findings underscore the importance of institutional support in sustaining inquiry-based science teaching. School leaders may promote effective inquiry pedagogy by prioritizing professional development that deepens teachers' understanding of inquiry design, scaffolding strategies, and formative assessment practices. Providing time for collaborative lesson planning and reflective dialogue among science teachers can further strengthen the quality and consistency of inquiry-based instruction across classrooms.



International Journal of Technology, AI and STEM Education

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ISSN (ONLINE): 3116-3718

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Directions for future research include examining the longitudinal effects of inquiry-based science instruction on learners' academic achievement, scientific literacy, and attitudes toward science. Long-term and mixed-methods studies may offer deeper insight into how sustained exposure to inquiry-based learning shapes learners' engagement trajectories and scientific competencies over time. Future research may also explore variations in inquiry implementation across different science disciplines and school contexts to inform scalable and context-sensitive models of inquiry-based science education.

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