Teachers' Embodied Experiences in the Next Generation Science Standards (NGSS): Towards a Proposed Enhancement Mentoring Framework

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Abstract

This study investigated the lived experiences of 10 Filipino science teachers implementing the NGSS during School Year 2025–2026. Guided by a qualitative descriptive phenomenological design, the inquiry included teachers with at least 1 year of experience implementing NGSS. Data was obtained through in-depth, audio-recorded interviews and examined using Colaizzi's seven-step phenomenological method. The participants' experiences reflected a gradual reconfiguration of science teaching practices. Instruction increasingly incorporates inquiry, hands-on activities, collaboration, and connections between scientific concepts and learners' experiences, moving beyond predominantly teacher-directed approaches. This transition was not without difficulty. Teachers encountered differences in student readiness, challenges in aligning assessments with the NGSS, limited instructional resources, and increased workload. In responding to these conditions, they drew on scaffolding, differentiated instruction, collaborative learning, reflective lesson planning, and continuing instructional support.

The analysis further indicated that NGSS implementation was influenced by the professional environment in which teachers worked. Collegial collaboration, administrative assistance, professional learning groups, and mentoring created avenues for sharing experiences, reconsidering instructional decisions, and working through implementation concerns. The findings thus position curriculum implementation as both an individual and organizational undertaking, with teachers' knowledge and skills interacting with the professional support available within their school. These findings informed the development of the Proposed Enhancement Mentoring Framework for NGSS Implementation. The framework provides a sustained, collaborative, practical, and context-responsive structure for professional support designed for Filipino science teachers working in multicultural international school settings. Its proposed components focus on strengthening pedagogical competence, professional confidence, reflective practice, and continuing professional growth while supporting the development and maintenance of meaningful NGSS-aligned classroom practices.

Keywords: Next Generation Science Standards (NGSS); embodied experiences; Filipino science teachers; descriptive phenomenology; mentoring framework; international schools; Kingdom of Saudi Arabia (KSA).

1. Introduction

Contemporary science education reform has increasingly emphasized learning experiences in which students construct scientific understanding through investigation, evidence-based reasoning, explanation, and application rather than primarily receiving scientific content through direct transmission. Within the Next Generation Science Standards (NGSS) framework, this orientation is reflected in the integration of disciplinary core ideas (DCIs), science and engineering practices (SEPs), and crosscutting concepts (CCCs). For teachers, however, the significance of this three-dimensional structure depends largely on how it is interpreted and enacted in classroom practice. Implementation requires teachers to make decisions regarding learning design, student participation, assessment, instructional resources, and professional support as they adapt established practices. These demands may become more complex when teachers implement a curriculum framework within an educational environment that differs from the system in which their initial professional knowledge and teaching practices were developed.

In an international school setting in Taif City, Saudi Arabia, 10 Filipino science teachers navigated these conditions while implementing the NGSS in their daily professional practice. Their professional backgrounds were largely shaped by the Philippine educational context, while their current practice required them to work with learners from diverse backgrounds and respond to the expectations of a different institutional environment. NGSS implementation therefore involved an ongoing process of interpretation and adaptation. Teachers had to determine how to make three-dimensional learning workable for their students, utilize available resources, and retain, modify, or reconsider established instructional practices. Curriculum implementation was consequently experienced through the concrete circumstances of teaching rather than independently of them.

The theoretical framework provided three complementary perspectives for understanding these experiences. Embodied Cognition Theory, drawing on Agostini and Francesconi (2021), highlights the relationship between cognition and engagement with physical, social, and instructional environments. From this perspective, teachers' professional understanding can be examined through their interactions with students, classroom activities, instructional materials, challenges, and decision-making processes. Phenomenology adds a focus on the meanings teachers attribute to these experiences. Pula (2022) supports an understanding of lived experience as a source of meaning, enabling the study to examine how teachers interpreted curriculum change within their everyday professional worlds. Teacher Identity Theory, in turn, provides a basis for examining how sustained exposure to new curricular expectations may influence teachers' perceptions of their roles and responsibilities as science educators.

Taken together, these perspectives allow curriculum implementation to be understood as more than observable compliance with NGSS requirements. Changes involving inquiry, collaboration, investigation, and student participation may influence how teachers organize classroom relationships and understand their professional roles. Instructional decisions may have cognitive and pedagogical implications while also generating emotional responses, embodied engagement, and reconsideration of professional responsibilities. The theories are therefore complementary: Embodied Cognition Theory illuminates situated engagement, Phenomenology examines the meaning of lived experience, and Teacher Identity Theory considers implications for professional self-understanding.

Despite substantial scholarship on NGSS implementation and teacher development, limited attention has been given to Filipino science teachers who bring professional experience from the Philippine educational system to NGSS implementation in international school contexts in Saudi Arabia. The research gap is not simply the absence of studies examining individual aspects of NGSS implementation, but the limited understanding of how cultural and institutional adjustment, instructional decision-making, emotional experiences, professional learning, and changing conceptions of teaching intersect within a transnational educational context. These dimensions may occur simultaneously during curriculum transition and therefore cannot always be meaningfully separated from teachers' lived experiences.

Colaizzi's descriptive phenomenological approach provided the methodological basis for examining this intersection. Drawing on participants' accounts, the study explored how teachers experienced three-dimensional learning, responded to implementation challenges, modified instructional practices, and interpreted changes in their professional work. Attention was directed toward the meanings embedded in everyday teaching experiences rather than solely toward formal NGSS expectations. This approach enabled curriculum reform to be examined within the actual circumstances in which teachers encountered and enacted it.

The participants' experiences also revealed implications for continuing professional support. Their accounts indicated needs related to instructional planning, inquiry-oriented teaching, assessment, collaboration, professional confidence, and adaptation to unfamiliar pedagogical expectations. These findings informed the development of a Proposed Enhancement Mentoring Framework for NGSS Implementation, conceptualized as sustained and context-responsive professional support rather than a one-time orientation. The framework integrates classroom experiences with opportunities for reflection, peer collaboration, professional guidance, and continuing professional learning to strengthen teachers' instructional capability and confidence in sustaining effective NGSS practices.

The study is also situated within broader educational commitments. Ambisyon Natin 2040 articulates a long-term Philippine vision focused on human development and improved quality of life, while Sustainable Development Goal 4 (SDG 4) promotes inclusive, equitable, and quality education and lifelong learning opportunities. Within these broader commitments, teachers' responses to changing curricular expectations and classroom demands are important considerations in strengthening educational practice.

Curriculum reform ultimately takes shape through teachers' professional work. Implementing new curricular expectations requires teachers to interpret requirements, reconsider established practices, and determine how these expectations can function within the learning needs, resources, and institutional conditions available to them. Accordingly, this study examined the lived experiences of Filipino science teachers as they translated NGSS expectations into classroom practice within an international school context.

Rather than framing NGSS implementation as the simple application of prescribed curriculum requirements, the study conceptualized it as a process of professional adaptation and change. Using Colaizzi's descriptive phenomenological approach, the inquiry examined teachers' lived experiences and identified implications for professional learning, instructional development, and mentoring. Based on these findings, the Proposed Enhancement Mentoring Framework was developed to provide sustained support for reflective practice, continuing professional development, and the effective integration of NGSS within an international educational setting.

2. Statement of the Problem

The inquiry examined how Filipino science teachers experienced and interpreted the implementation of the NGSS in an international school setting in Taif City, Saudi Arabia. Attention was given to teachers' experiences of NGSS-related instructional expectations, the professional adjustments required in practice, and the contextual conditions that influenced curriculum implementation in their classrooms.

The study was guided by one central research question and four corollary questions:

Central Question

How did Filipino science teachers describe their embodied experiences while implementing the NGSS in their classrooms?

Corollary Questions

1. What challenges and adjustments do teachers encounter in applying the NGSS's three-dimensional learning framework?
2. What meanings may be formulated from their embodied experiences?
3. What themes emerged from the formulated meanings?
4. Based on the findings, what enhancement mentoring framework may be proposed?

3. Research Methodology

Research Design

The study employed a qualitative descriptive phenomenological design to examine the lived experiences of 10 Filipino science teachers implementing the Next Generation Science Standards (NGSS) in an international school in Taif City, Saudi Arabia. The inquiry focused on how teachers experienced, interpreted, and responded to NGSS-related instructional expectations within their professional contexts.

The design was appropriate because NGSS implementation required teachers to facilitate inquiry, promote student participation and evidence-based reasoning, and integrate disciplinary core ideas (DCIs), science and engineering practices (SEPs), and crosscutting concepts (CCCs). Teachers translated these expectations through lesson planning, classroom interaction, instructional decision-making, and adaptation of established practices.

The study was guided by Embodied Cognition Theory, Phenomenology, and Teacher Identity Theory. Embodied Cognition Theory situated teachers' experiences within their physical, social, emotional, and instructional environments. Phenomenology focused on the meanings teachers attached to their lived experiences, while Teacher Identity Theory examined how curriculum change influenced teachers' professional self-understanding.

Colaizzi's Seven-Step Descriptive Phenomenological Method was used to analyze the interview data. Transcripts were repeatedly reviewed, significant statements were identified, formulated meanings were developed, and related meanings were organized into thematic clusters. These clusters were synthesized into an exhaustive description and an essential structure of the phenomenon. Participant validation was conducted to strengthen the credibility and fidelity of the interpretation.

The findings provided the empirical basis for the Proposed Enhancement Mentoring Framework for NGSS Implementation. The framework addressed identified needs related to instructional adaptation, inquiry-based teaching, teacher confidence, professional agency, cultural adjustment, and continuing professional development.

Data Generation

Data were generated through in-depth interviews with 10 Filipino science teachers working in an international school in Taif City, Saudi Arabia. The participants brought professional knowledge and teaching experience developed within the Philippine educational system into an international educational context characterized by different curricular, institutional, and cultural conditions.

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The interviews elicited participants' experiences of NGSS implementation, including instructional changes, classroom challenges, adaptations, professional judgments, and changing perceptions of their roles as science educators. This approach allowed participants to describe their experiences in their own terms rather than being limited to predetermined categories.

With informed consent, interviews were audio-recorded and transcribed verbatim. The transcripts served as the primary textual data for phenomenological analysis and included accounts of three-dimensional learning, instructional modifications, implementation challenges, and teachers' responses to curriculum demands.

Ethical Considerations

Ethical safeguards were observed throughout recruitment, data collection, analysis, and reporting. Participants received information about the study and interview procedures and provided written informed consent, including permission for audio recording. Participation was voluntary, and participants could decline questions or withdraw without penalty.

Confidentiality was maintained by removing identifying information and using participant codes or pseudonyms. Research materials were securely stored and accessed only for research purposes. These measures protected participants while allowing them to discuss their experiences openly.

Data Transcription and Management

Audio-recorded interviews were transcribed verbatim and checked against the original recordings to identify omissions and transcription errors. Only minor formatting adjustments were made to improve readability without changing participants' intended meanings.

Participants were assigned numerical identifiers, and identifying information was removed or replaced before analysis and reporting. Audio files, transcripts, and related research records were securely stored. An audit trail documented key decisions during transcription, coding, organization, and interpretation, supporting transparency and analytical rigor.

Data Analysis

Colaizzi's Seven-Step Descriptive Phenomenological Method was used to analyze the interview data. The researcher first immersed in the transcripts through repeated reading and listening to the recorded interviews. Significant statements relevant to NGSS implementation were then identified and interpreted within their narrative contexts.

Formulated meanings were organized into thematic clusters representing recurring dimensions of teachers' experiences, including curriculum transition, instructional adaptation, classroom practice, emotional responses, and professional development needs. The clusters were synthesized into an exhaustive description and an essential structure of the phenomenon. Emerging interpretations were continually compared with the original transcripts to maintain consistency with participants' accounts.

The resulting phenomenological interpretation served as the empirical foundation for the Proposed Enhancement Mentoring Framework for NGSS Implementation. The framework was grounded in the teachers' identified needs and experiences rather than imposed independently of the findings.

Trustworthiness and Rigor

Trustworthiness was established through credibility, dependability, confirmability, and transferability. Credibility was supported through participant validation and repeated comparison of significant statements, formulated meanings, and thematic clusters with the original transcripts.

Dependability was strengthened through systematic documentation of methodological and analytical decisions. Confirmability was supported by maintaining a clear evidentiary connection between participants' accounts and the resulting interpretations, together with peer debriefing. Transferability was addressed by providing relevant contextual information about the participants, international school setting, and conditions surrounding NGSS implementation.

Collectively, these procedures established a transparent chain of evidence from participants' narratives through phenomenological analysis to the study's interpretation and proposed mentoring framework.

4. Results and Discussion

Table 1. Significant Statements, Formulated Meanings, and Clustered Themes Relevant to the Central Question

ID	Significant Statements	Formulated Meanings	Clustered Themes
1	*"My embodied experiences in implementing NGSS revolve around actively engaging students in inquiry-based and student-centered learning."*	NGSS implementation was experienced as students' active involvement in inquiry and student-centered learning. (1)	Transformation toward Student-Centered and Inquiry-Based Science Teaching
1	*"I experience NGSS as a framework that encourages students to at least actively participate in scientific investigations, critical thinking, and problem-solving rather than simply memorizing scientific facts."*	NGSS was interpreted as an approach that encouraged investigation, critical thinking and problem solving instead of memorization. (1)	
2	*"I experienced how NGSS encourages learners to become active participants in learning rather than passive receivers of information."*	NGSS changed the way learners learn from passive to active. (2)	
3	*"Actually, implementing NGSS in my science classroom has transformed my role from being a traditional lecturer into a facilitator of authentic scientific inquiry."*	The lecturer's position has changed from one of old teacher to one of a facilitator of real scientific inquiry. (3)	
3	*"So instead of simply delivering concepts just like what other traditional teachers do, I guide my students in asking questions."*	Teaching moved away from the delivery of content, towards asking students to ask questions about science. (3)	
3	*"Because my reasoning is that students are no longer passive listeners. They become active thinkers and problem solvers."*	Students were turned from listeners to thinkers, problem solvers. (3)	
4	*"The best practices that will manifest or show NGSS is that when you do teaching, you always start with an experiment and then the students will be the ones to do the experiments with you as a facilitator inside the classroom."*	The lessons were experiential with students as the actors and teacher as facilitator. (4)	
7	*"Implementing NGSS has transformed my teaching into a more dynamic and collaborative process."*	Teaching had become a process of collaboration and dynamism in the NGSS implementation. (7)	
8	*"At the same time, they are encouraged to have a student-centered learning wherein inquiry-based approach is also applied rather than focusing on memorization."*	Emphasis was placed on student-centered, inquiry-based learning and away from memorization. (8)	
9	*"As a science 4 teacher in an international school here in Saudi, implementing NGSS has made my teaching more student-centered and inquiry-based."*	NGSS implementation had resulted in more inquiry-based and student-centered education. (9)	
9	*"I experience teaching as more interactive and engaging because students are encouraged to ask questions, investigate, and explain scientific phenomena rather than simply memorize facts."*	Teaching was interactive and engaging with questioning, investigation and explanation instead of memorization. (9)	
10	*"For me, I'd say that NGSS is actually more like a shift toward more student-centered and inquiry-based teaching where students just actively explore and construct their understanding rather than just merely possibly receiving information."*	NGSS was felt as a shift toward student centered inquiry where students were actively building up their knowledge. (10)	
1	*"Well, in my day-to-day teaching, I experience NGSS by integrating inquiry-based activities, collaborative discussions, laboratory investigations, and even real-world applications into my lessons."*	Inquiry, collaboration, laboratory investigation, and real-world application were seen daily in NGSS teaching. (1)	Hands-On, Phenomenon-Based, and

1	*"I think it includes hands-on laboratory activities, project-based learning, engineering design tasks, group investigations, and evidence-based discussions."*	NGSS classroom practices included hands-on activities, projects, engineering design, group investigation, and discussion based on evidence. (1)	Real-World Science Learning
1	*"I also incorporate phenomenon-driven lessons that connect scientific concepts to real-world situations."*	Phenomenon-driven lessons related science to real world situations. (1)	
2	*"In my day-to-day teaching, I apply NGSS by integrating inquiry-based learning, problem-solving activities, experimentation, and real-world applications."*	The strategy of implementing inquiry, problem-solving, experimentation, and real-world application occurred daily. (2)	
2	*"For example, when I'm teaching biology, I encourage students to investigate environmental issues and explain biological processes using evidence-based reasoning instead of memorizing concepts alone."*	Biological learning was linked with the investigation of the environment and reasoning with evidence instead of memorizing. (2)	
2	*"So the best classroom practices that best reflect my implementation of NGSS include project-based learning, collaborative investigation, differentiated instruction, performance tasks, and integrating real-world scientific issues."*	NGSS implementation was evidenced through project-based learning, collaborative investigations, differentiation, performance tasks, and real-world issues. (2)	
2	*"So this process improved my ability to connect science concepts to real-life situations and made more reflective as an educator."*	Real-life connections in teaching were strengthened and educator reflections were encouraged with NGSS implementation. (2)	
3	*"Every lesson becomes dynamic, interactive, and reflective of real-world scientific experiences."*	Lessons were dynamic, interactive and linked to real world scientific experiences. (3)	
3	*"And then after that, they will construct explanations, design models, and solve problems connected to their daily lives."*	Students built explanations, developed models and solved problems in real world contexts. (3)	
3	*"So this approach makes science more meaningful and socially relevant."*	NGSS put science into a meaningful, socially relevant context. (3)	
3	*"I could say it includes phenomenon-based learning. And one of the things that my students enjoy is the hands-on laboratory activity."*	Phenomenon-based learning and lab practice were significant classroom practices. (3)	
3	*"I often observe learners becoming more curious and confident when they realize that science is not confined to textbooks, but exists within their own experiences and communities."*	Pupils' interest and self-assurance in science grew when science was linked to their lives and their societies. (3)	
4	*"However, most of the things that we have in NGSS is that it's a real-life application of what they will be having when they are going in the fields of sciences."*	NGSS was perceived as putting classroom science into the future of science and scientific careers. (4)	
4	*"Of course, apply science in real situations, and think like a scientist and engineer."*	Science learning included opportunities to apply science and to think like scientists and engineers. (4)	
4	*"And then you have to apply it in real life situations so that the students would really understand or master the concept."*	The application of real life was used to enrich students' understanding and mastery of concepts. (4)	
6	*"Well, most I can say is modeling. We also use argumentation from evidence, hands-on investigation, and of course, phenomena-based situational activities."*	Modelling, argumentation with evidence, investigation, and phenomena-based activities were evidence of NGSS practices. (6)	
7	*"I experience teaching as more engaging because students actively explore scientific concepts through inquiry, experimentation, and discussion."*	Students were engaged in teaching as a result of their inquiry, experimentation, and discussion. (7)	
7	*"NGSS has encouraged me to focus more on critical thinking, scientific reasoning, and real-world applications."*	NGSS guided instruction in critical thinking, scientific reasoning and application. (7)	
7	*"NGSS is reflected through inquiry activities, collaborative investigations, and project-based learning."*	NGSS implementation was observed through inquiry activities, collaborative investigations and project-based learning. (7)	
8	*"I experience NGSS implementation in my classroom where I encourage my students to be more on hands-on experiences."*	The NGSS implementation included having students engage in hands-on experiences. (8)	
8	*"In terms of my daily teaching, students are also active, they explore a lot, they investigate."*	Teaching was through active learning and investigation on a daily basis. (8)	
8	*"At the same time, given scientific concepts rather than simply focusing on textbooks, so hands-on experiences and real-life applications are also provided."*	Teaching of scientific concepts was not just from textbooks, but in terms of real-life experiences and activities. (8)	
9	*"I usually begin my lessons using real life phenomena that connects science concepts to students' experiences."*	Real-life phenomena have been used to start lessons to make the science concepts relatable to students' experiences. (9)	
9	*"Students actively participate in experiments and collaborative learning tasks."*	Pupils engaged well in practical activity and learning together. (9)	
10	*"I think since I'm a science teacher, the best practices include hands-on investigations, phenomenon-based learning, collaborative group work, and when the students use evidence to explain their scientific ideas."*	NGSS practice was evident in hands-on investigation, phenomenon-based learning, collaboration, and evidence-based explanation. (10)	
1	*"I regularly encourage students to ask questions, investigate phenomena and analyze evidences, and even explain scientific concepts using critical thinking skills."*	Students were led to ask questions, investigate, analyze evidence and explain scientific concepts in a critical manner. (1)	Active Facilitation, Evidence-Based Meaning-Making, and Three-Dimensional Learning
2	*"So during lessons on genetics, for example, students conduct collaborative investigations, analyze data, and present scientific explanations."*	Learning genetics with the approach of collaborative investigation, data analysis and scientific explanation. (2)	
2	*"So this reflects the NGSS principles of combining disciplinary core ideas, science and engineering practices, and cross-cutting concepts."*	The classroom implementation involved the integration of the three dimensions of NGSS. (2)	
3	*"Sometimes I do argumentation from evidence. We do have engineering design tasks. And of course, the most important thing is the performance-based assessment."*	Teaching included argumentation from evidence, engineering design, and performance-based assessment. (3)	
4	*"Basically, the first thing that we are doing is to let the student ask questions, investigate problems, analyze evidences, develop explanations."*	Pupils were questioning, investigating, analyzing evidence and developing explanations. (4)	
4	*"Students must think like a scientist in order for them to internalize all the learnings that they have in physics."*	There was a need for thinking science so that students would internalize the learning of physics. (4)	
5	*"And the most important, based on the three dimension, and I have to make sure that it is really implemented well to make sure that the students are learning based on the standards provided."*	Implementation needed to focus on the three dimensions and on how well students are meeting the expected standards. (5)	
5	*"For me, I have to say that it's the cross-cutting from the dimension."*	Crosscutting connections were considered to be a key component of NGSS classroom practice. (5)	
6	*"So, every lesson is more of like an experience rather than a prepared plan."*	Lessons were felt as on-going learning events and not as plans for learning. (6)	
6	*"So, you have to constantly guide students with probing questions and applied investigations."*	There was a need for constant guidance in the form of probing questions and applied investigations in the teaching. (6)	
6	*"So, every day is like giving them a probing activity and applied sessions, and then we follow it up right with constant formative assessments."*	Probing activities, application sessions, and ongoing formative assessment occurred daily during teaching. (6)	
7	*"Engineering design tasks, collaborative experiments, scientific argumentation, and performance-based assessments best reflect NGSS practices in my classroom."*	Classroom practice was characterized by engineering design, experiments, scientific argumentation, and performance assessment. (7)	
8	*"At the same time, they will be given scaffolded activities, experimentations, hands-on learning experiences, discovery approach, critical questions were also provided so that they are provoked to think deeply and make meaning of the lessons."*	Further thinking and meaning making were encouraged through scaffolding, experimentation, discovery and critical questioning. (8)	
9	*"I also use performance-based assessments where students explain concepts using evidence instead of relying only on written tests."*	For performance-based assessment students were asked to explain concepts based on evidence. (9)	
10	*"When it comes to day-to-day teaching, since this is reflected in the curriculum that we use here in the daily classroom teaching, it's just embodied into the lessons that we have, into the activities that we have in our lessons."*	NGSS was experienced as being integrated into everyday classroom activities and lessons. (10)	
1	*"Physically, I become actively involved in facilitating experiments, monitoring student participation, and guiding collaborative activities in the classroom."*	Physical engagement was expressed as a facilitator of experiments, as a monitor of participation, as a guide of collaboration. (1)	Physical Demands and Preparation in NGSS
2	*"So physically, implementing NGSS requires constant classroom movement, preparation of materials, laboratory supervision, and facilitation of group activities."*	Physical experiences included ongoing mobility, material preparation, supervision within the lab and group facilitation. (2)	

3	*"Maybe my embodied experiences are deeply physical. We can say emotional and cognitive because NGSS requires active engagement, not only from students, but also from the teacher."*	Due to the need for active teacher and student engagement, the NGSS implementation was experienced physically, emotionally and cognitively. (3)	Implementation
3	*"In terms of physical, I think implementing NGSS is demanding."*	Implementation of NGSS was felt as physically challenging. (3)	
4	*"In terms of preparation, it's hard because I'm not into science."*	It was challenging for a non-science subject teacher to plan NGSS-based physics lessons. (4)	
4	*"In preparation, that's hard because I'm teaching math and then I have to prepare things in physics so that these students will have the opportunity to have their experiments."*	If an experimental lesson had to be given in Physics, it was necessary to have extra preparation by a mathematics specialist. (4)	
4	*"In physical preparations, it's quite exhausting because you have to find things. Sometimes things in the laboratory are not available."*	The physical preparation was very tiring as they had to be sought in the face of the limited laboratory facilities. (4)	
6	*"Well, in using NGSS, it feels like it's teaching with your body and mind fully engaged."*	The NGSS teaching was felt to be very demanding physically and mentally. (6)	
6	*"So, physically, it is quite exhausting because you have to be always ready."*	Physical experience was tiring as one had to be ready all the time. (6)	
7	*"Physically and mentally, it requires consistent preparation and active classroom facilitation."*	There had to be consistent preparation and active facilitation needed for NGSS implementation. (7)	
8	*"So physically, teaching NGSS really requires constant movement across the classroom just to facilitate it meaningfully and effectively."*	Physical experience included movement in the classroom in order to facilitate effectively. (8)	
9	*"Physically, I move constantly around the classroom facilitating group work and experiments."*	Physical experience included moving when conducting experiments and group work. (9)	
10	*"For me, physically, I'm more active in facilitating the activities. I usually move around the classroom, prepare the materials."*	Physical experience was defined as active facilitation, movement in the classroom, and preparing materials. (10)	
1	*"Emotionally, I feel motivated and fulfilled when students demonstrate curiosity, engagement, and deeper understanding of scientific concepts."*	Students' curiosity, engagement, and understanding led to emotional fulfillment. (1)	Emotional Fulfillment, Challenge, and Instructional Pressure
2	*"My experiences in implementing the next-generation science standards have been both challenging and meaningful."*	The implementation of NGSS was found to be a challenge and yet a purpose. (2)	
2	*"Emotionally, the experience can be demanding yet fulfilling."*	The NGSS implementation was an emotional journey and was rewarding. (2)	
2	*"However, I also experience fulfillment and excitement whenever students become more engaged, curious, and confident in expressing scientific ideas."*	Students were engaged, curious and confident to express scientific ideas, which led to fulfillment and excitement. (2)	
3	*"Emotionally, I can say it is both fulfilling and exhausting."*	Emotional experience was one of satisfaction and drain. (3)	
4	*"Emotionally, sometimes it's exciting because you yourself also are learning from your students."*	Emotional experience included excitement arising from learning together with students. (4)	
5	*"I describe it as interesting because new method should be used, and other materials also should be used."*	NGSS implementation was interesting, as it involved new methods and materials. (5)	
5	*"I find it interesting as well, and also at the same time challenging, because making sure that materials are available, making sure also that my students are engaged with whatever activity we are doing inside the classroom using the NGSS standards, and I have to make sure as well that my assessment is aligned to the expected output of the students."*	NGSS was interesting and challenging as it needed materials, engagement, and assessment alignment. (5)	
5	*"Manifestations, there will be excitement, it's because learning more right from the process, and also discovering the strength of the student using the techniques and using the standards."*	Emotional experience was provided: excitement of learning through the process, discovering students' strengths. (5)	
6	*"So, it's mostly a mix of pressure and daily surprises from the students' part."*	The NGSS teaching included pressure on the one hand, and on the other hand, unexpected student reactions, and discoveries. (6)	
6	*"Emotionally, you feel, most of the time, you feel stretched but energized."*	Emotional experience was a feeling of being stretched yet energized. (6)	
7	*"Emotionally, I feel satisfied seeing students become independent learners and problem solvers."*	Satisfaction arose from seeing students become independent learners and problem-solvers. (7)	
8	*"Emotionally, I could say that I feel both challenged and fulfilled because students become more engaged and curious."*	Emotions were about challenge and fulfilment within student engagement and curiosity. (8)	
9	*"Emotionally, I feel motivated when students show excitement and curiosity."*	Motivation was found in the students' excitement and curiosity. (9)	
10	*"When it comes to emotionally, I think I can feel hope, fulfillment when students are engaged, and sometimes pressure when the lessons are quite demanding."*	Emotional experience: hope and fulfilment in engagement, pressure in challenging lessons. (10)	
1	*"Through this approach, I have become more reflective, adaptive, and collaborative in my teaching practices."*	Implementation of NGSS had made teaching more reflective, adaptive, and collaborative. (1)	Reflective, Adaptive, and Cognitively Demanding Teaching Practice
1	*"Cognitively, I constantly analyze students' responses, adjust instructional strategies, and reflect on lesson effectiveness to ensure that learning objectives are achieved."*	The cognitive involvement involved constant analysis, teaching adaptation and reflection on the effectiveness of the lesson. (1)	
2	*"Cognitively, NGSS challenged me to think critically and creatively about lesson planning and instructional delivery."*	In terms of cognitive, critical and creative thinking was needed in the planning and teaching of lessons. (2)	
3	*"Cognitively, I think NGSS challenges me to continuously rethink my instructional strategies, assessment methods, and content delivery to ensure alignment with three-dimensional learning."*	Cognitive experience included continuous reconsideration of strategies, assessment and content delivery for three-dimensional alignment. (3)	
3	*"The latest thing that I have discovered and improved in my teaching is the integration of artificial intelligence, especially when I am using games."*	AI was investigated as a way to enhance interactive science training. (3)	
4	*"Cognitive experiences, of course, since I'm a math major, I have to really put 100% or more than 100% in understanding basically too technical terms."*	The cognitive experience was very difficult when it came to comprehending technical physics concepts outside the teacher's field of expertise. (4)	
6	*"So, you have to juggle in between concepts, science practices, all at once."*	Cognitive experience involved the simultaneous focus on concepts and science practices. (6)	
7	*"Cognitively, I continuously analyze how to make lessons more meaningful and connect to the NGSS framework."*	Cognitive engagement was characterized by ongoing efforts to make meaning of lessons, and to make lessons fit with NGSS. (7)	
8	*"Cognitively, NGSS pushes me to think critically as well."*	The NGSS forced the teacher to critically consider instruction and learning. (8)	
9	*"Cognitively, NGSS challenges me to think critically about lesson design and how to connect science concepts, practices, and cross-cutting ideas effectively."*	Cognitive experience included critically designing lessons that incorporated ideas, practices, and crosscutting ideas. (9)	
10	*"But cognitively, I think that NGSS, it requires deeper planning and the integration of some scientific practices, the core ideas, and the cross-cutting concepts that it actually involves."*	Cognitive experiences needed more NGSS dimensions to be integrated and more planning. (10)	

Organization of Formulated Meanings into Theme Clusters Relevant to the Central Question

Analysis of the participants' accounts generated six thematic clusters: (1) transformation toward student-centered and inquiry-based science teaching; (2) hands-on, phenomenon-based, and real-world science learning; (3) active facilitation, evidence-based meaning-making, and three-dimensional learning; (4) physical demands and preparation; (5) emotional fulfillment, challenge, and instructional pressure; and (6) reflective, adaptive, and cognitively demanding teaching practice. Collectively, these themes indicate that NGSS implementation represented a multidimensional transformation of teachers' professional practice rather than the adoption of isolated instructional strategies.

Transformation toward Student-Centered and Inquiry-Based Teaching

Participants described a shift from teacher-directed content delivery toward student-centered and inquiry-based instruction. Students increasingly engaged in questioning, investigation, evidence analysis, and construction of scientific understanding, while teachers assumed greater responsibility as facilitators of inquiry. As Participant 3 stated, the experience involved a transition from being a "traditional lecturer" to a "facilitator of authentic scientific inquiry."

Hands-On, Phenomenon-Based, and Real-World Learning

NGSS implementation also encouraged teachers to connect science concepts with observable phenomena, laboratory investigations, collaboration, and real-world experiences. Participants emphasized that science learning extended beyond textbooks toward active engagement with phenomena and students' everyday contexts.

Evidence-Based and Three-Dimensional Learning

Teachers described increased emphasis on questioning, evidence analysis, explanation, and scientific reasoning. The integration of DCIs, SEPs, and CCCs required teachers to design learning experiences in which students constructed and justified scientific understanding. This repositioned teachers as facilitators of evidence-based meaning-making rather than primarily as transmitters of content.

Physical and Emotional Demands

Participants reported that inquiry-oriented instruction increased physical demands associated with classroom movement, material preparation, laboratory supervision, and facilitation. These demands were accompanied by both fulfillment and pressure. Teachers expressed motivation when students demonstrated curiosity and independence, while also describing the implementation process as challenging and exhausting.

Reflective and Adaptive Teaching Practice

NGSS implementation required continuous planning, reflection, assessment, and instructional adjustment. Teachers described analyzing student responses and refining strategies to maintain alignment among DCIs, SEPs, and CCCs. Implementation was therefore experienced as an iterative process requiring sustained professional judgment and cognitive engagement.

Emergent Theme: Embodied Transformation of Science Teaching

The six themes converged in the emergent theme Embodied Transformation of Science Teaching through NGSS Implementation. NGSS implementation was experienced not merely as curricular adoption but as a transformation of teachers' professional practice involving changes in pedagogy, student participation, teacher facilitation, physical engagement, emotional experience, and cognitive work. The transition from content delivery toward inquiry, collaboration, evidence-based reasoning, and real-world learning also influenced how teachers understood their professional roles.

Overall, the findings suggest that NGSS implementation involved an interconnected process of pedagogical, cognitive, emotional, physical, and professional transformation. While the transition required substantial preparation and adaptation, teachers also associated it with increased student engagement, curiosity, independence, and meaningful scientific learning.

Table 2. Significant Statements, Formulated Meanings, and Clustered Themes Relevant to the Corollary Question 1

ID	Significant Statements	Formulated Meanings	Clustered Themes
1	*"One of the major challenges I encountered in implementing NGSS three-dimensional learning framework is balancing the integration of science and engineering practices, disciplinary core ideas, and cross-cutting concepts within limited classroom time."*	The three dimensions of NGSS were difficult to integrate into time-limited lessons. (1)	Difficulty in Integrating the Three Dimensions within Limited Instructional Time
1	*"The main difficulties, I think, include designing lessons that meaningfully connect all three dimensions while ensuring that students fully understand the scientific concepts being taught."*	Teaching in a way that integrated all three dimensions so that conceptual understanding was maintained was difficult. (1)	
2	*"One major challenge that I encounter in applying NGSS three-dimensional learning framework is balancing content knowledge with inquiry-based and performance-based activities."*	There was a lot of teaching adjustment that needed to happen to balance content with inquiry and performance-based activities. (2)	
2	*"Another challenge involved is the time constraint. So inquiry-based activities, laboratory work, and collaborative investigation require more preparation time and classroom time compared to traditional lecture."*	More time for preparation and instruction was required for inquiry, laboratory work and collaboration, than for the traditional lecture. (2)	
3	*"Maybe I can say one of the major challenges in implementing NGSS is integrating the three dimensions simultaneously."*	It was a challenge to combine all three NGSS dimensions simultaneously. (3)	
3	*"So balancing this dimension within limited classroom time can be, of course, difficult."*	Three-dimensional learning was constrained due to the limited time spent in classroom. (3)	
5	*"One is the collaboration with other subjects, especially if the topic is something that other subjects doesn't have a connection to, because I have to make sure in cross-cutting that I have to limit the topic and at the same time collaborating with other subjects so that the students will not be overwhelmed."*	Careful interdisciplinary collaboration was needed to prevent overload of the students in applying crosscutting connections. (5)	
6	*"So, the biggest challenge would be trying to put all those three dimensions of NGSS seamlessly."*	The challenge to seamlessly integrate all three NGSS dimensions was considered a big challenge for teaching. (6)	
6	*"But to integrate all the practices and the cross-cutting concepts requires preparations."*	It took a lot of preparation to ensure incorporation of scientific practices and crosscutting concepts. (6)	
6	*"Another time is also an issue for NGSS lessons. It takes longer sometimes for the students to explore the actual principles or the theories involved in each lessons."*	A thorough understanding of science principles needed more teaching time than was typically provided. (6)	
6	*"And as a teacher, you will have mostly have to slow down and choosing fewer deeper lessons to meet the NGSS expectations."*	To meet NGSS expectations, fewer ideas had to be taught and learned at a deeper level. (6)	
7	*"For me, one major challenge is designing lessons that fully integrate scientific practices, cross-cutting concepts, and core ideas while meeting curriculum expectations."*	It was a challenge to create integrated NGSS lessons that also met curriculum requirements. (7)	
8	*"Implementing this three-dimensional framework is a big challenge because balancing content, the knowledge, scientific processes or practices, and even cross-cutting concepts really requires careful lesson planning in more classroom time."*	Careful planning and additional classroom time was needed to balance content, scientific practices, and crosscutting concepts. (8)	
9	*"One challenge I think is balancing the integration of science practices, those disciplinary core ideas within limited class time."*	It was hard to balance science practices and disciplinary core ideas due to limited time in class. (9)	
9	*"The main difficulty is ensuring that all three dimensions are equally addressed in one lesson."*	It was difficult to ensure a balance of all three NGSS dimensions in one lesson. (9)	
10	*"I would say that the main difficulty when it comes to integrating the three dimensions, um, is balancing disciplinary core ideas, the science and engineering practices, which can be really challenging, especially for the lower grades, and cross-cutting concepts all at once within a single lesson."*	It was challenging to create lessons that incorporate all three NGSS dimensions, especially at the lower levels. (10)	
1	*"Because students also have varying levels of readiness and critical thinking skills, which can make inquiry-based learning challenging."*	Students' readiness and critical thinking skills were not at the same level, so it was not easy to facilitate inquiry-based learning. (1)	Students' Difficulty in Adapting to Inquiry-Based and Conceptually Deeper Learning
2	*"Some student initially struggled with critical thinking, scientific reasoning, and independent learning because they are more familiar with a teacher-centered instruction."*	Students were accustomed to teacher-centered instruction and needed support to help them develop reasoning and independent learning skills. (2)	
6	*"Sometimes, students struggle to connect the practices to the concept."*	Students struggled to make connections between science practices and concepts. (6)	
7	*"Another challenge is that addressing by valuing student abilities and learning styles."*	Student abilities and learning styles were different and needed to be addressed in responsive instructional planning. (7)	
7	*"Some struggling to connect investigations with scientific explanations and broader concepts."*	Students needed assistance to connect investigations with explanations and other scientific ideas. (7)	
8	*"And difficulties, students must demonstrate deeper understanding of the lesson and not just depend on mere memorization."*	NGSS mandated that students' progress beyond memorization to higher levels of understanding. (8)	

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8	*"I think the students sometimes struggle to connect the concepts with real-world applications."*	The students required support in transfer of scientific concepts to real world context. (8)	
9	*"Because some students also struggle with inquiry-based learning because they are more familiar with traditional teacher-centered instruction."*	Learners who are used to teacher-centered learning struggled to adjust to inquiry learning. (9)	
9	*"Sometimes, students focus more on activities and less on connecting concepts."*	Students did activities without making proper connections to the science concepts. (9)	
1	*"To address these challenges, I usually use differentiated instruction, scaffolded inquiry activities, collaborative learning strategies, and guided questioning techniques."*	Students were provided with differentiation, scaffolding, collaboration and guided questioning to support them in inquiry learning. (1)	Instructional Adjustment through Scaffolding, Differentiation, and Collaborative Inquiry
2	*"So to address this, I gradually scaffold activities by providing structured guides, graphic organizers, and guided questioning techniques."*	Students found it easier to adapt to inquiry-based learning with structured guides, graphic organizers and guided questioning. (2)	
3	*"Some students adapt quickly to inquiry based learning while others, of course, you have to expect that others struggle because they are more accustomed to a teacher-centered instruction."*	There was a need for scaffolding for students who were not used to inquiry-based learning. (3)	
3	*"I scaffold learning experiences by breaking down complex investigations into manageable steps."*	To make scientific inquiry accessible and engaging to all students, investigations were broken down into manageable steps. (3)	
3	*"I also incorporate localized and low-cost material to make investigation accessible and relevant."*	Local, cheap materials were suitable substitutes for scientific investigation. (3)	
6	*"So, most of the time, I will have to shift from teacher-led explanations to student-generated perspectives."*	The NGSS implementation demanded that students' meaning making became a priority instead of teacher instruction. (6)	
7	*"I adjust by differentiating instruction, using technology, and providing structured inquiry activities."*	Various different approaches, differentiated instruction, technology, and structured inquiry, were used to meet the needs of different students. (7)	
7		The use of scaffolding, visual organizers, guided questioning, and collaboration facilitated students' understanding of integrated concepts. (7)	
8	*"For me, I provide scaffolding, visual organizers, and guided questions and collaborative tasks to support understanding."*	Inquiry, collaboration, and scaffolding were used to make NGSS lessons more manageable. (8)	
9	*"So to address these challenges, I simplify activities like scaffold instructions and provide more guided support during investigations."*	Students engaged in investigations with simplified tasks, scaffolding and guided support. (9)	
10	*"I think the best way to adjust my teaching strategies to address these challenges would be by, uh, by scaffolding the lessons, breaking the task into smaller steps, and encouraging cooperative learning to support the understanding of my students."*	Students' understanding was supported by scaffolding, manageable sequences of tasks, and cooperative learning. (10)	
2	*"So adjusting to this shift a demanded significant changes in my instructional strategies."*	In order to move towards NGSS oriented instruction, changes in established practices were needed. (2)	Need for Teacher Preparation, Content Mastery, and Professional Adaptation
4	*"The thing is that I have to study the things that I have to do before I execute the lesson."*	Adopting NGSS-based science teaching demanded careful pre-planning prior to instruction. (4)	
4	*"In science, it's a combination of equations and the concepts."*	In the science teaching, the relationship between concepts and mathematical processes had to be made. (4)	
4	*"It's difficult to apply the concepts in calculating. If you don't know the concept, how can you be able to calculate?"*	This was a challenge to teaching physics when conceptual and mathematical aspects were not well related. (4)	
4	*"The first adjustment is going, asking guidance, asking questions to my science teachers, co-workers, so at least they could give me ideas."*	The consultation and advice of colleagues helped them adjust to teaching unfamiliar or challenging science content. (4)	
4	*"And then the second one is watching videos in YouTube and other educational videos so that I can be able to simplify the concepts on how I could apply NGSS into physics and how I can be able to effectively teach physics to the students."*	Content videos were provided to boost content knowledge and to ease physics teaching using NGSS. (4)	
10	*"The main challenge that I have encountered when it comes to applying this NGSS is that it's new to me."*	It proved a challenge to know NGSS well, especially if you had a different curriculum background. (10)	
10	*"So I think learning the NGSS framework was basically the main challenge, how I'm going to apply it to my lessons while adhering to the concepts that I must deliver as well."*	The new framework required professional adaptation and learning while delivering the required concepts. (10)	
5	*"Sometimes, we have to identify if the effectivity of the NGSS is really visible inside a classroom based on the evaluation, and sometimes I have to use the evaluation tool in order for me to check if it is really effective."*	There was a need to evaluate the effectiveness of NGSS implementation in the classroom using suitable evaluation tools. (5)	Challenges in Assessment Alignment and Monitoring of Standards
5	*"And if I can see that there is a lack of congruency, then I have to do re-teaching, and it takes time."*	Reteach, and extra time required due to misalignment with expected standards and student outcomes. (5)	
5	*"At the same time, it takes another effort for a teacher to make sure that the standards are met, so this could be one of the challenges."*	To meet NGSS standards, extra work was required beyond the normal lesson delivery. (5)	
5	*"One of the adjustments is to make sure that the evaluation is really aligned to NGSS, is to make sure that I will give extra effort and then extra evaluation or follow-up evaluation in order for me to really assess the effectivity of the program or the standards."*	NGSS standards were assessed by aligned and follow-up assessments to determine if they were being met. (5)	
8	*"So assessment could be also a challenge."*	Assessment was a challenge in the 3-D learning implementation. (8)	
1	*"Time constraints, limited resources, and differences in students' learning abilities also create challenges in maintaining active engagement and deeper understanding during lessons."*	Sustainability of engagement and greater understanding were difficult due to limited time, resources and differing learning capabilities. (1)	Limitations in Time, Laboratory Facilities, Instructional Materials, and Collaborative Planning
3	*"One of the difficult things to solve because inquiry-based investigation often requires laboratory materials, especially technological tools, and we cannot deny the fact that it also requires a flexible learning environment."*	No materials, technology, or flexible learning spaces were easily available, which limited inquiry-based investigations. (3)	
4	*"And then what is lacking, I think the laboratory is limited to handle all science subjects."*	Science activities were limited across subject areas due to limited laboratory capacity. (4)	
6	*"So, collaborative planning is always a matter of issue because it has to be done in constant scheduling."*	Because of scheduling challenges between school sections, collaborative planning was limited. (6)	
7	*"More time for lesson planning and additional science equipment would improve implementation further."*	To enhance implementation of NGSS, more preparation time and science equipment were required. (7)	
8	*"I think, sir, professional development. At the same time, peer collaboration and the ready-to-use NGSS-aligned materials are very helpful, while limited time and insufficient resources remain as challenges also."*	Limited time and resources were barriers to implementation, which was also supported by professional development, peer collaboration and aligned materials. (8)	
9	*"Helpful resources include digital simulations, science kits, and collaborative planning with colleagues, of course."*	Digital simulations, science kits, and collegial planning were found to be useful resources to support the use of NGSS. (9)	
1	*"I think continuous professional development, sufficient laboratory materials, and access to NGSS-aligned instructional resources are often lacking in some educational settings."*	For successful implementation of the NGSS, the need for continuous training, adequate laboratory materials, and aligned instructional resources were identified. (1)	Need for Sustained Professional Development, Mentoring, and Collegial Support
2	*"So to adjust these challenges, I continuously improve my teaching strategies through professional development, collaboration with my colleagues, and reflective practice."*	Teacher development, collaboration, and reflection were employed to enhance NGSS teaching strategies. (2)	
2	*"However, more training opportunities focus specifically on NGSS implementation, assessment strategy, and inquiry-based pedagogy would further strengthen teachers' confidence and competence."*	Teachers needed to have focused training that would enhance their competence and confidence in NGSS, assessment and inquiry pedagogy. (2)	
3	*"However, more sustained mentoring, maybe. I can say training. And of course, NGSS-aligned resources are still needed to help teachers implement the framework effectively and confidently."*	Confident implementation required sustained mentoring, training and NGSS aligned resources. (3)	
5	*"So far, trainings and also support from the organization is still not fully visible because some of science teachers are still using the old method or the traditional way of teaching science."*	The continued use of traditional science teaching approaches was attributed to the limited science organizational training and support. (5)	
9	*"However, more NGSS-focused professional development and digital laboratory materials would further support implementation."*	More professional development and online lab tools focused on NGSS were needed. (9)	

Organization of Formulated Meanings into Theme Clusters Relevant to the Corollary Question 1

Colaizzi's phenomenological analysis generated seven thematic clusters describing the principal challenges and adaptive responses associated with NGSS three-dimensional learning: Difficulty in Integrating the Three Dimensions within Limited Instructional Time; Students' Difficulty in Adjusting to Inquiry-Based and Conceptually Deeper Learning; Instructional Adjustment through Scaffolding, Differentiation, and Collaborative Inquiry; Need for Teacher Preparation, Content Mastery, and Professional Adaptation; Challenges in Assessment Alignment and Monitoring of Standards; Limitations in Time, Laboratory Facility, Instructional Materials, and Collaborative Planning; and Need for Sustained Professional Development, Mentoring, and Collegial Support.

Difficulty in Integrating the Three Dimensions within Limited Instructional Time

Participants reported difficulty integrating DCIs, SEPs, and CCCs within limited instructional periods. Inquiry, laboratory work, collaborative investigation, and evidence-based explanation required substantial preparation and classroom time. Consequently, teachers had to balance curriculum expectations with the time necessary for meaningful three-dimensional learning.

Students' Difficulty in Adjusting to Inquiry-Based and Conceptually Deeper Learning

Some students experienced difficulty adjusting to inquiry-based learning because of their familiarity with teacher-centered approaches. Challenges included independent learning, scientific reasoning, and connecting investigations with scientific concepts. Teachers therefore provided structured guidance to gradually develop students' inquiry skills, conceptual understanding, and evidence-based reasoning.

Instructional Adjustment through Scaffolding, Differentiation, and Collaborative Learning

Teachers addressed student and instructional challenges through scaffolding, differentiated instruction, guided questioning, structured inquiry, and collaborative learning. These strategies provided students with appropriate support while progressively encouraging independent inquiry and evidence-based explanation.

Need for Teacher Preparation, Content Mastery, and Professional Adaptation

Participants identified preparation, content mastery, and professional adaptation as important requirements for NGSS implementation. Teachers described studying unfamiliar content, modifying instructional strategies, and seeking guidance from colleagues and other resources. These experiences demonstrate the need for continuous professional learning during curriculum implementation.

Challenges in Assessment Alignment and Monitoring of Standards

Assessment presented challenges because NGSS implementation required evaluation of understanding, application, reasoning, and performance rather than recall alone. Teachers needed to align assessments with NGSS expectations, monitor student proficiency, and provide follow-up instruction when learning gaps emerged.

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Limitations in Time, Laboratory Facility, Instructional Materials, and Collaborative Planning

Participants identified limited time, laboratory facilities, instructional materials, technology, and collaborative planning opportunities as constraints on NGSS implementation. These conditions affected teachers' ability to consistently provide inquiry-based and three-dimensional learning experiences.

Need for Sustained Professional Development, Mentoring, and Collegial Support

Participants emphasized the need for sustained professional development, mentoring, collegial collaboration, NGSS-aligned resources, and organizational support. Such support was viewed as important for strengthening teachers' confidence and capacity to address implementation challenges effectively.

Emergent Theme Relevant to Corollary Question 1: Navigating the Complexities of Three-Dimensional Learning through Adaptive Instruction and Sustained Support

The seven thematic clusters converged into Navigating the Complexities of Three-Dimensional Learning through Adaptive Instruction and Sustained Support. This emergent theme reflects NGSS implementation as an ongoing process of reconciling three-dimensional learning with student readiness, instructional time, available resources, assessment requirements, and professional demands.

Participants responded through scaffolding, differentiation, guided questioning, collaborative learning, reflection, and collegial consultation. However, the findings indicate that effective implementation required more than individual teacher competence. Adequate resources, planning time, assessment alignment, professional development, mentoring, and institutional support were also necessary. Thus, NGSS implementation emerged as both an instructional and professional adaptation process and provided the empirical basis for the Proposed Enhancement Mentoring Framework for NGSS Implementation.

Table 3. Significant Statements, Formulated Meanings, and Clustered Themes Relevant to the Corollary Question 2

ID	Significant Statements	Formulated Meanings	Clustered Themes
1	*"Okay, from my experiences in implementing NGSS, I realized that science education should focus more on inquiry, application, and real-life understanding or authentic understanding rather than rote memorization."*	Science education was grasped to be inquiry, life relevant and aimed for real understanding and not memorization. (1)	Inquiry-Based, Real-Life, and Meaningful Science Learning
1	*"Okay, for me, NGSS implementation means creating a learning environment where students are actively engaged in scientific inquiry and real-world problem-solving."*	NGSS was interpreted as a process of developing an active learning environment based upon inquiry and real-world problem solving. (1)	
2	*"NGSS taught me that science teaching should not only focus on transmitting knowledge, but also on developing students' curiosity, critical thinking, collaboration, and problem-solving skills."*	It was believed that good science teaching was not just about giving away information but was about developing curiosity, reasoning, collaboration and problem solving. (2)	
2	*"So I realized that meaningful learning occurs when students actively engage in scientific inquiry and connect lessons to real-life world experiences."*	Science learning was defined as meaningful learning, which is learning as activity and is related to real life experiences. (2)	
3	*"Instead of focusing solely on factual recall, I now emphasize understanding, application, and scientific reasoning."*	Science, now, was no longer just about memorization but was about comprehension, application, and scientific thinking. (3)	
4	*"So at least using NGSS, they're immersed in different applications, they're immersed in different concepts of science, not just head knowledge but also practice, also applications."*	NGSS was seen as linking science, what it can do, and how it can be done. (4)	
6	*"So, it means that when you're teaching something like NGSS, you are more involved in investigative processes."*	Science teaching was interpreted as engaging in a process of investigation. (6)	
6	*"Well, when we started implementing NGSS, I come to finally realize how real science lessons works. It's messy. It should not be very restrictive."*	Flexible, open and not too controlled were the expectations of authentic science teaching. (6)	
7	*"I have shifted from focusing mainly on content delivery to emphasizing inquiry, collaboration, and application of knowledge."*	The approach to science teaching had shifted from teaching content to inquiry, collaboration, and applications. (7)	
9	*"Well, implementing NGSS has helped me realize that science learning should be meaningful and connected to real-world experience."*	It was perceived that science learning was meaningful when there was a connection to real world experience. (9)	
10	*"Um, as a science teacher, I say that it means promoting inquiry, critical thinking, real-world application of scientific concepts, rather than just the usual rote learning and memorization."*	It was interpreted that NGSS was about inquiry, critical thinking, and real-world application as opposed to rote memorization. (10)	
10	*"It shifted toward, uh, valuing student exploration, active learning, and just a deeper conceptual understanding, I'd say."*	The attitude to science learning had changed to learning through exploration, active learning and conceptual understanding. (10)	
1	*"NGSS has helped me see science teaching as a process of guiding students to think critically, solve problems, and relate scientific concepts to real-life experiences."*	The role of science teachers was seen as facilitating students' thinking, problem solving, and applications to real life. (1)	Transformation of Teaching Identity

1	*"These actually have transformed my teaching identity from being primarily a content provider to becoming a facilitator of learning."*	The role of a teacher had shifted to a facilitator of learning rather than content provider. (1)	toward Facilitation and Mentorship
2	*"I no longer see myself as simply as a lecturer, but also a facilitator of learning who guides students in discovering knowledge through meaningful experiences."*	The identity of the teacher had changed from lecturer to facilitator that led to meaningful discovery of knowledge. (2)	
6	*"Well, in implementing NGSS, you can appreciate me on how I see myself as a science teacher. So, we have all these ideas from traditional moving to the facilitator type of thinking."*	The changes of self-understanding were from traditional teacher to as facilitator of learning as a result of NGSS implementation. (6)	
6	*"I can now identify myself more on like a co-investigator."*	The role of teaching had evolved to become more of a co-investigator to students. (6)	
6	*"I now identify myself more as a coach."*	With the NGSS implementation, an identity of a learning guide or coach had been created. (6)	
7	*"I now see myself more as a mentor and facilitator who guides students through inquiry and exploration."*	The focus on teaching had been transformed to mentorship and facilitating inquiry and exploration. (7)	
8	*"As a science teacher for two years, it really shaped my identity. So they helped me become more student-centered."*	An NGSS identity as a student-centered teacher emerged. (8)	
8	*"I now view science teaching as guiding my students to explore and solve problems, instead of simply delivering the lesson and spoon-feeding them with the concepts they need."*	Science teaching was conceived as a process of directing the process of exploration and problem solving instead of providing concepts. (8)	
9	*"Strengthened my identity as a facilitator who guides students toward critical thinking and problem-solving rather than memorization."*	The teaching identity had been enhanced to become facilitation in critical thinking and problem solving and not memorization. (9)	
10	*"When it comes to my teaching identity, I think these experiences have transformed me in a way that from being a content transmitter, I've actually developed more as a facilitator of student learning."*	The role of the teacher had changed from the transmitter of knowledge to the facilitator of learning. (10)	
1	*"I now recognize the importance of allowing students to ask questions, investigate phenomena, and construct their own understanding through active participation."*	Science teaching had become one of questioning, investigation and active construction of understanding. (1)	Active Student Participation and Collaborative Meaning-Making
3	*"However, over time, I realized that authentic science learning involves exploration. Of course, let the students ask questions in collaborative meaning-making."*	Authentic science learning was interpreted as exploration, questioning and collaborative meaning making. (3)	
4	*"One, teachers and students are partners of learning."*	The teachers and students were known to be partners in the learning process. (4)	
4	*"So in NGSS, there is an active participation or active, how do you call this, active roles between the teacher and the students."*	NGSS implementation was seen as a role of teachers and students. (4)	
5	*"So we have to make sure that the program can be implemented by proper differentiation so that other students that are challenged especially with the subject can still cope up."*	NGSS implementation was seen as a need for differentiation for struggling students to join and to meet the rigors of learning. (5)	
6	*"So, I come to value student struggle as a part of learning."*	Pupils' struggle was respected as a valuable aspect of the learning process. (6)	
6	*"So, when NGSS was introduced, I believe that now that real good teaching means creating more opportunities for students to develop themselves and to construct more learning without us dominating mostly the classroom environments."*	Teaching effectiveness was recognized as the opportunity for students' knowledge construction and development, which is not dominated by teachers. (6)	
7	*"NGSS has taught me the importance of creating meaningful learning experiences where students actively construct knowledge."*	Meaningful science learning was interpreted as students actively building their knowledge. (7)	
8	*"My experiences with NGSS have made teaching more meaningful because my students become more active participants in learning rather than being passive learners."*	When students were active and not passive, teaching was more meaningful. (8)	
8	*"They are more collaborative. They get engaged with the lessons from start to finish."*	Collaboration and continued engagement of students were considered to be important results of NGSS implementation. (8)	
9	*"I now see science teaching as an active learning process where students discover concepts through inquiry and collaboration."*	The notion of teaching science was seen as one of active learning, learning through inquiry, and learning through collaboration. (9)	
1	*"I have become more reflective, flexible, and responsive to students' needs while encouraging active participation and critical thinking in the classroom."*	There was a more reflective, flexible and responsive teaching practice for NGSS implementation. (1)	Reflective, Adaptive, and Continuing Professional Growth
2	*"So my embodied experiences in implementing NGSS have deepened my understanding of what it truly means to become an effective science educator."*	There had been an increase in the understanding of good science teaching because of NGSS experiences. (2)	
2	*"So NGSS implementation strengthened my commitment to lifelong learning and continuous professional growth."*	There was an increased commitment to lifelong learning and continuing professional development as a result of NGSS implementation. (2)	
3	*"Maybe my experiences with NGSS have reshaped my understanding of what it truly means to teach science."*	The nature of science teaching had been refashioned through experience with NGSS. (3)	
3	*"Implementing NGSS has strengthened my identity as both an educator and, of course, lifelong learner."*	The NGSS implementation had helped develop an identity of "educator committed to continuing learning. (3)	
3	*"Implementing NGSS means embracing uncertainty and growth."*	NGSS implementation was seen as embracing uncertainty and teacher development for inquiry-based teaching. (3)	
4	*"But at least experiencing such things gives me another experience that I can also try aside from teaching math. I can also try teaching physics and learning at the same time from these experiences and from experiences of my students."*	Professional expansion and shared learning with students had become opportunities for teaching physics using NGSS. (4)	
5	*"Meaning making for me is having a reflection of NGSS so far because this is still a challenge for most of the teachers that we have in the field."*	Meaning-making was the activity of reflecting on NGSS as an ongoing professional challenge. (5)	
5	*"For me, this challenge is mainly tough because I really need to cope with whatever are the needs in my classroom."*	The need to meet the evolving needs in the classroom had influenced the teaching of identity. (5)	
5	*"So I have to adjust even the emotions, I have to adjust it as well my resources and even my techniques in teaching and strategies can also be adjusted based on what is being asked."*	Emotional, material and pedagogical adjustment was required in the implementation of NGSS. (5)	
5	*"For me, this is a part of evolution of teaching at the same time."*	NGSS was interpreted as part of an ongoing process of science education reform. (5)	
5	*"It made me, yes it made me tough, it made me realized as well that there is always room for improvement and there is always room for innovation."*	NGSS experiences had enhanced resilience and openness to improvement and innovation. (5)	
8	*"They make me reflective. At the same time, flexible and as an adaptable teacher."*	Reflectiveness, flexibility and adaptability in teaching had been achieved in the process of NGSS implementation. (8)	
8	*"It means a lot to me, sir, as a science teacher because it not only encourages curiosity to my students, at the same time, it builds my curiosity as well as their teacher."*	NGSS fostered student curiosity and rekindled curiosity in the teacher. (8)	
9	*"Well, these experiences made me more effective, flexible, and student-centered in my teaching approach."*	NGSS experiences had evolved a more effective flexible and student-centered pedagogy. (9)	
10	*"The meanings that I actually derive from my experiences in, uh, implementing NGSS, I'd say that, um, it depends on the lesson that we have and on the set of students that I'm currently dealing with."*	The interpretation of what it means to implement NGSS was that it is flexible to the lesson and specific students involved. (10)	
2	*"For me, implementing NGSS means preparing students not only for academic success, but also for real-life challenges."*	NGSS was seen as preparing students for academic success and for real world problems. (2)	Preparation for Scientific Literacy, Future Application, and Responsible Citizenship
3	*"NGSS has taught me that science education should not simply transfer knowledge, but also cultivate curiosity, critical thinking, problem-solving, and responsible citizenship."*	Science education was conceived not only as a transfer of knowledge, but as an ability to learn through inquiry and an ability to be good citizens. (3)	
4	*"And the other thing is that there is a real-life embodiment of the concepts. It's not just a classroom-based experience, but since we are doing what we are experiencing in the future, so I think that's one of the meanings."*	Scientific concepts were meaningful when presented in real-life and future-oriented experiences. (4)	
4	*"Okay, so NGSS application is something that we can use in the future."*	NGSS was interpreted as learning that would lead to students doing things in the future. (4)	
7	*"It means helping students connect science to real-world issues and preparing them to think critically and solve problems."*	NGSS was seen as equipping students with the ability to use science "to solve real world problems" by engaging them in critical thinking and problem solving. (7)	
9	*"NGSS means preparing students to become scientifically literate individuals who can apply scientific thinking in real-life situations."*	NGSS was perceived to be an introduction to and preparation for scientific literacy, and the use of scientific thinking in real life. (9)	

Organization of Formulated Meanings into Theme Clusters Relevant to the Corollary Question 2

The formulated meanings converged into five theme clusters: Inquiry-Based, Real-Life, and Meaningful Science Learning; Transformation of Teaching Identity toward Facilitation and Mentorship; Active Student Participation and Collaborative Meaning-Making; Reflective, Adaptive, and Continuing Professional Growth; and Preparation for Scientific Literacy, Future Application, and Responsible Citizenship. These clusters reflected participants' embodied experiences and illustrated changes in the purpose of science instruction, teacher and student roles, and the broader value of science learning.

Inquiry-Based, Real-Life, and Meaningful Science Learning

Participants viewed NGSS as shifting science education from memorization toward inquiry, application, and authentic understanding. They emphasized opportunities for students to ask questions, investigate phenomena, and construct understanding through active participation. Thus, science learning was perceived as more meaningful when connected to real-life contexts and authentic inquiry.

Transformation of Teaching Identity toward Facilitation and Mentorship

Participants described a transformation in their teaching identity from content providers and lecturers toward facilitators, mentors, coaches, and guides. Their role increasingly involved creating opportunities for students to discover knowledge through meaningful experiences. This shift reflected a broader change in teachers' understanding of their professional responsibilities under NGSS.

Active Student Participation and Collaborative Meaning-Making

Participants emphasized students' active participation and the partnership between teachers and learners. NGSS was perceived as fostering collaborative classroom environments in which students contributed to the construction of knowledge rather than remaining passive recipients. Meaning-making was consequently understood as a shared process involving interaction, participation, and engagement.

Reflective, Adaptive, and Continuing Professional Growth

Participants described NGSS implementation as encouraging reflection, flexibility, adaptation, and continuous professional improvement. Teachers recognized the need to reconsider instructional practices, respond to students' needs, and remain open to innovation and lifelong learning. NGSS was therefore experienced as contributing not only to instructional change but also to continuing professional growth.

Preparation for Scientific Literacy, Future Application, and Responsible Citizenship

Participants viewed NGSS as extending beyond immediate academic achievement toward preparing students for real-life challenges and future application of scientific knowledge. They emphasized scientific literacy, critical thinking, problem-solving, and responsible citizenship. Science education was consequently understood as a means of preparing learners to apply scientific thinking and knowledge beyond the classroom.

Emergent Theme Relevant to Corollary Question 2: Reframing Science Teaching as Inquiry-Driven, Facilitative, and Life-Relevant Learning through NGSS

The five theme clusters converged into the emergent theme Reframing Science Teaching as Inquiry-Driven, Facilitative, and Life-Relevant Learning through NGSS. This theme captured a broader transformation in how participants understood the purpose of science instruction and their professional roles.

Participants experienced NGSS as shifting science teaching from the transmission and recall of facts toward inquiry, application, collaboration, and meaning-making. Students were increasingly viewed as active participants who questioned, investigated, explained, and connected scientific concepts with real-life situations.

This instructional transformation was accompanied by changes in teacher identity. Participants increasingly viewed themselves as facilitators, mentors, coaches, co-investigators, and partners in learning rather than primarily as lecturers or content providers. Their role centered on creating conditions for inquiry, collaboration, meaning-making, and application of scientific understanding.

The findings further indicated that this transformation required continuous reflection and adaptation. Participants described science teaching as increasingly inquiry-driven, collaborative, facilitative, and connected to students' lives, while emphasizing scientific literacy, future application, and responsible citizenship. Overall, NGSS represented a reorientation of science teaching toward inquiry, meaningful participation, professional reflection, and life-relevant learning.

Table 4. Significant Statements, Formulated Meanings, and Theme Clusters Relevant to Corollary Question 3

ID	Significant Statements	Formulated Meanings	Clustered Themes
1	*"At the same time, meaningful student engagement and active participation somehow consistently emerge as important indicators of successful implementation."*	Student participation and meaningful engagement were considered to be signs of successful NGSS implementation. (1)	Active Student Engagement through Inquiry-Based Learning
2	*"So the first theme is student engagement through active learning."*	A consistent way of enhancing student engagement was to use active learning. (2)	
2	*"So students become more motivated and interested when they participate in hands-on investigation, collaborative activities, and real-world problem-solving tasks."*	The students became motivated and interested because they investigated, collaborated and solved real-world problems. (2)	
2	*"Student motivation, participation, and cooperation greatly affects the success of the classroom implementation."*	The success of classroom implementation was impacted by student motivation, participation and cooperation. (2)	
3	*"And of course, students benefit from peer interaction, cooperative investigations, and group problem-solving tasks."*	Student learning was benefitted by peer interaction, cooperative investigation and group problem-solving. (3)	
4	*"One that NGSS is an active learning idea or something like that."*	NGSS was an approach to active learning. (4)	
4	*"Because as I've mentioned, there is an active role that is happening between the students and the teacher."*	Teachers and students were actively engaged in NGSS learning experiences. (4)	
4	*"And the rest of the thing, the teacher will just facilitate the lesson and then the students will be the ones who will demonstrate, simulate, who will explain, who will analyze concepts."*	NGSS placed the teacher in the role of facilitator, with students demonstrating, simulating, explaining and analyzing scientific concepts. (4)	
7	*"A recurring theme is that they become more confident when they participate."*	There was a correlation between student involvement and greater confidence. (7)	
8	*"If I'm going to identify recurring patterns, that would be the student engagement, at the same time, collaboration, adaptability, and the continuous teacher learning as well as student learning."*	Four themes of student engagement, collaboration, adaptability and ongoing teacher and student learning were consistent throughout the observations. (8)	
1	*"Practices like hands-on investigations, collaborative discussions, contextualized learning activities, even project-based learning, and the use of real-world phenomena consistently contribute to effective NGSS implementation."*	Effective implementation was supported by approach through hands-on investigation, collaboration, contextualized learning, projects, and real-world phenomena. (1)	Real-World, Phenomenon-Based, and Experiential Science Learning
3	*"Maybe one recurring theme is the importance of student engagement through real-world relevance."*	An important foundation for student engagement was real-world relevance. (3)	
3	*"Because I do believe that students learn more effectively when lessons connect with their personal experiences, community concerns, and societal issues."*	When views of the community and society were linked to the contents of science classes, learning was more effective. (3)	
3	*"Inquiry becomes more meaningful when learners see the practical value of science in their everyday life."*	The meaning of inquiry occurred when students understood the relevance of science in everyday life. (3)	
4	*"Another thing is that NGSS provides real life opportunities for the students to grow holistically."*	There were opportunities for students to learn through real life experience, which was seen as promoting students' all-round development. (4)	
4	*"They provide experiences inside the classroom which are rich in information, which are rich in experiences so that the students will grow."*	High quality classroom experiences were seen to assist students' development. (4)	
4	*"One is the, of course you have to provide different simulations or activities to activate students' learning."*	To activate student learning, simulations and activities were used. (4)	
4	*"And the thing is that we provide, we try to bring inside the classroom what they will be seeing in the future."*	Classroom learning was connected with situations that students could encounter in the future. (4)	
6	*"Well, a recurring theme is mostly students thrive when they learn with real phenomena."*	Students were observed to make a successful learning using real phenomena. (6)	
8	*"Hands-on investigation, sir. At the same time, providing inquiry-based learning, discovery learning, collaborative discussions, and of course, showing consistent support will be really effective in terms of building concepts and meaning-making of learning for my science students."*	Conceptual meaning-making was enhanced through hands-on investigation and inquiry, discovery learning, collaboration, and continuous support. (8)	
10	*"To assure effective implementation, I'd say that effective practices include hands-on activities, phenomenon-based lessons, collaboration, and strong questioning strategies."*	Implementation was effective with the use of hands-on activities, phenomena-based lessons, collaboration, and good questioning. (10)	
1	*"Okay, I think in NGSS implementation, it includes adaptability, collaboration, inquiry-*	NGSS implementation was marked by flexibility, teamwork, inquiry and ongoing	Teacher

	based learning, and continuous professional growth."	professional development. (1)	Adaptability, Preparedness, and Continuous Professional Growth
2	*"So the second theme is teacher adaptability and continuous learning."*	The patterns of teacher adaptability and ongoing learning were identified as key ones in the implementation of NGSS. (2)	
2	*"Implementing NGSS requires teachers to become flexible, reflective, and innovative."*	Teachers had to be flexible, reflective, and innovative in their practice in order to implement NGSS. (2)	
3	*"So despite these difficulties, teachers who remain flexible, reflective, and open to innovation tend to implement NGSS more successfully."*	Teachers' use of NGSS was bolstered by flexibility, reflection and willingness to try something new. (3)	
4	*"One, you have to be prepared as a teacher in applying NGSS."*	Teacher readiness was seen as crucial in implementation of NGSS. (4)	
6	*"And I also noticed that NGSS implementation is most successful when you as a teacher, you feel comfortable and you are given more time to plan and construct your lessons."*	Implementation had been effective based on teacher confidence and planning time. (6)	
1	*"Teachers also commonly experience the need for continuous professional development and collaboration to effectively implement inquiry-based learning strategies."*	Continuous professional development and collaboration were needed to support inquiry-based implementation. (1)	Collaboration, Mentoring, and Institutional Support
1	*"It includes teachers' preparedness, administrative support, availability of resources, collaboration among teachers, and access to professional development opportunities."*	The successful implementation was dependent upon teacher preparedness, administrative support, resources, collaboration, and professional development. (1)	
2	*"Okay, so another recurring theme is the importance of collaboration and support system."*	Important conditions for implementation were collaboration and support systems. (2)	
2	*"Effective NGSS implementation become more successful when teachers collaborate through mentoring, professional learning communities, and peer sharing."*	Implementation was enhanced through mentoring, professional learning communities and peer sharing. (2)	
3	*"I also believe that collaboration consistently contributes to effective implementation."*	Collaboration always facilitated good NGSS implementation. (3)	
3	*"Similarly, teachers need professional collaboration and mentoring to sustain NGSS practices."*	Professional collaboration and mentoring were needed to sustain teachers' NGSS practices. (3)	
5	*"It is because some teachers have the same difficulties, some challenges. We share the same goals and standards."*	The teachers faced similar issues and pursued common standards and objectives. (5)	
5	*"Similar experiences that we share and the good thing is that we share experiences for us to come up with better options, better solutions, and also better strategies that our learners or students need to learn."*	The exchange of experiences helped teachers to come up with better solutions and strategies for learners. (5)	
6	*"Another pattern that is most effective as a theme is the collaboration between students and teachers. That's really essential."*	The importance of working together between teachers and students in the implementation was felt. (6)	
6	*"Factors influencing success or difficulty to us teachers would be well, the administrative support is a major factor for teachers, well, in any other departments, okay, to successfully implement their plans."*	Administrative support had a strong impact on teacher implementation of NGSS plans. (6)	
7	*"For me, teacher preparedness, student motivation, resource availability, and administrative support strongly influence implementation."*	Teacher preparedness, student motivation, resources, and administrative support influenced implementation. (7)	
8	*"That would be, of course, teacher preparedness, the support from the administration, access to resources, professional development, so I think all of these strongly influence the implementation and the success of this NGSS."*	Success of implementation was highly related to teacher preparedness and administrative support and resources, as well as professional development. (8)	
9	*"For this, sir, student readiness, teacher training, availability of resources, and administrative support all influence implementation success."*	Implementation success was related to student readiness, teacher training, resources, and administrative support. (9)	
10	*"Personally, I'd say that the factors that influence this successful and challenging experience, I think it depends on the preparedness of the teacher, the resources that we have, the support from the mentors and administration, while lack of time, training, and materials are actually what creates the challenges."*	There was support for implementation in the form of teacher preparedness, resources, teacher mentoring, and administration support, and there were challenges in the form of limited time, teacher training, and materials. (10)	
1	*"Many teachers nowadays experience similar challenges related to time constraints, limited resources, and the need for continuous adjustment in instructional practices."*	Time constraints, lack of resources and ongoing instructional adjustments were identified as challenges to teaching. (1)	Persistent Constraints in NGSS Implementation
1	*"Yes, many teachers share common experiences such as difficulty in integrating all three dimensions of NGSS, adjusting to student-centered instruction, and managing limited classroom resources."*	The challenges that were commonly reported among teachers included implementing the NGSS dimensions, getting away from teacher-centered approaches to learning, and the scarcity of resources. (1)	
2	*"Teachers also share experiences related to time constraint, workload, and adapting to changes in teaching strategies and technologies."*	Common teacher experiences included time limitations, work load and getting used to new strategies and technology. (2)	
3	*"A common challenge among teachers is maybe balancing curriculum demands with authentic inquiry."*	Many teachers found balancing curriculum demands and authentic inquiry to be a challenge. (3)	
5	*"Recurring patterns or themes that I can identify is about the technology itself."*	Issues of technology kept reappearing as a concern in the implementation of NGSS. (5)	
5	*"The technology itself is something that even teachers are having difficulties identifying what are the appropriate technologies that they use especially with implementing new generation standards."*	The teachers had problems finding suitable technology to use for NGSS implementation. (5)	
6	*"We kind of mostly have a struggle shifting between traditional teaching to the student-centered inquiries, which is mostly the focus of NGSS."*	Teachers found it difficult to move away from teaching towards students' inquiry. (6)	
6	*"So, for me, sometimes I feel really overwhelmed and preparing instructions for the students."*	Preparing NGSS instruction was experienced as overwhelming. (6)	
7	*"Many teachers experience challenges with assessment methods as well as time management and transitioning students to inquiry-based learning."*	Common implementation challenges were assessment, aligning with time management, and moving toward inquiry-based learning. (7)	
8	*"Among the teachers that I have worked with, our common experience would be related to time, managing time, so at the same time, assessment, evaluation, and of course, resource availability during the implementation of this NGSS."*	Time management, assessment, evaluation and resources availability were experiences common to teachers. (8)	
9	*"Yes, sir. Actually, many teachers experience challenges with time management, adapting students to inquiry-based learning."*	Challenges common to both were time management and students' adaptation to the inquiry-based learning approach. (9)	
10	*"When it comes to themes, I'd say, uh, I can identify, like, the challenges are, they're not, they're not, they're not like repetitive, but it's, it just rotates on one single problem, usually the lack of instructional materials."*	A common implementation issue was the lack of instructional materials. (10)	
10	*"Sometimes students are actually having a difficulty when it comes to grasping the concepts and integrating the science and engineering practices that comes along with it."*	Students struggled to comprehend ideas and apply science and engineering practices. (10)	
10	*"I'd say that many teachers often experience similar challenges when it comes to integrating the three dimensions and shifting to inquiry-based instruction."*	The three dimensions and transition to inquiry teaching were common teacher challenges. (10)	
2	*"So practices that consistently contribute to effective implementation include proper lesson planning, the use of interactive and learner-centered activities, and integrating technology and localized materials and instruction."*	Effective implementation was due to lesson planning, learner-centered activities, technology and localization of materials. (2)	Assessment and Instructional Practices Supporting Successful Implementation
5	*"One best practice is the continuous training, how to handle this, how to implement this properly, and also proper assessment with the alignment for every standards that we have."*	Training and evaluation based on standards were considered a key practice for implementation. (5)	
5	*"The biggest factor for me is the result because this will identify if you've been an effective science teacher, if you've been an effective NGSS implementer."*	The performance of students was seen as evidence of effectiveness of teacher and implementation. (5)	
5	*"So the evaluation, the result from the student's outcome and behavior is something that we really need to look into."*	An assessment of student outcomes and behavior was needed to assess success in implementation. (5)	
6	*"But the outcome when you see the students learn the lessons is really rewarding."*	The act of watching the students' learning provided teachers with a satisfaction in the implementation of NGSS. (6)	
6	*"As per my experience, mostly these are clear anchoring phenomena, structured discourse routines, and consistent formative assessment or more like a flexible formative assessment."*	NGSS implementation was supported by anchoring phenomena, a structured discourse, and formative assessment. (6)	
7	*"Student-centered learning, inquiry activities, collaboration, as well as formative assessments consistently contribute to successful implementation."*	Successful implementation was achieved through student-centered learning, inquiry, collaboration, and formative assessment. (7)	
9	*"Hands-on learning, collaboration, questioning techniques, and formative assessments contribute greatly to effective implementation."*	Effective implementation was due to the hands-on learning, collaboration, questioning, and formative assessment. (9)	

Organization of Formulated Meanings into Theme Clusters Relevant to Corollary Question 3

The formulated meanings were organized into six theme clusters: Active Student Engagement through Inquiry-Based Learning; Real-World, Phenomenon-Based and Experiential Science Learning; Teacher Adaptability, Preparedness, and Continuous Professional Growth; Collaboration, Mentoring and Institutional Support; Persistent Constraints in NGSS Implementation and Assessment; and Instructional Practices Supporting Successful Implementation. These themes reflected participants' embodied experiences and identified conditions and practices associated with effective NGSS implementation.

Active Student Engagement through Inquiry-Based Learning

Participants identified active student engagement as a central feature of successful NGSS implementation. Students were increasingly involved in inquiry, collaboration, explanation, problem-solving, and hands-on activities rather than primarily receiving scientific information through teacher-directed instruction. Engagement was associated with increased motivation, confidence, and participation. Teachers consequently viewed active student involvement as an important indicator of meaningful NGSS learning.

Real-World, Phenomenon-Based and Experiential Science Learning

Participants emphasized that science learning became more meaningful when connected to real-world phenomena, community experiences, hands-on investigations, simulations, and practical applications. Contextualized and experiential activities helped students connect scientific concepts with everyday experiences and supported deeper meaning-making.

Teacher Adaptability, Preparedness, and Continuous Professional Growth

NGSS implementation required teachers to become flexible, reflective, innovative, and prepared to modify established instructional practices. Participants emphasized planning, confidence, continuous learning, and willingness to adapt as important conditions for successful implementation. Professional growth was therefore viewed as an ongoing process accompanying curricular change.

Collaboration, Mentoring and Institutional Support

Participants identified collaboration, mentoring, professional development, resources, and administrative support as important conditions for sustaining NGSS implementation. Collegial interaction enabled teachers to exchange experiences, develop solutions, and refine instructional strategies, while institutional support provided guidance and resources. Thus, implementation was experienced as a shared professional process rather than an individual teacher responsibility.

Persistent Constraints in NGSS Implementation and Assessment

Despite enabling practices, participants reported persistent constraints involving instructional time, workload, resources, technology, assessment, and students' adjustment to inquiry-based and student-centered learning. These challenges affected teachers' ability to consistently integrate the three NGSS dimensions and sustain desired instructional practices.

Instructional Practices Supporting Successful Implementation

Participants identified lesson planning, learner-centered activities, inquiry, questioning, collaboration, hands-on learning, localized materials, technology, formative assessment, and monitoring of student outcomes as practices supporting effective NGSS implementation. These practices helped teachers align instruction and assessment with NGSS expectations while monitoring student learning.

Emergent Theme Relevant to Corollary Question 3: Enacting Meaningful NGSS Learning through Engagement, Adaptation, Collaboration, and Sustained Support amid Persistent Constraints

The six thematic clusters converged into the emergent theme Enacting Meaningful NGSS Learning through Engagement, Adaptation, Collaboration, and Sustained Support amid Persistent Constraints. The theme captures NGSS implementation as a dynamic process involving active student engagement, inquiry-based and real-world learning, teacher adaptability, collaboration, mentoring, institutional support, and aligned assessment.

Participants' experiences indicated that meaningful implementation depended on teachers' preparedness, flexibility, reflection, and continuous professional learning, supported by collaboration and institutional assistance. At the same time, implementation remained shaped by persistent constraints involving time, resources, technology, workload, assessment requirements, student readiness, and the integration of the three dimensions. Thus, effective NGSS implementation emerged as a balance between engagement, adaptation, collaboration, and sustained support within existing practical and instructional constraints.

Table 5. Significant Statements, Formulated Meanings, and Clustered Themes Relevant to Corollary Question 4

ID	Significant Statements	Formulated Meanings	Clustered Themes
1	*"Mentoring and support mechanisms for NGSS implementation should focus on continuous professional development, collaboration, and practical classroom application."*	In-service, co-operation and implementation of NGSS in the classroom were recognized as core elements of NGSS mentoring. (1)	Sustained and Practical Classroom-Based Mentoring
1	*"Teachers need sustained support systems that could help them improve instructional practices and adapt effectively to the demands of NGSS implementation."*	Sustained support systems were required to enhance teacher behavior and help teachers adjust to NGSS requirements. (1)	
1	*"I think a mentoring that is practical, collaborative, and directly connected to classroom experiences are what teachers need."*	Teachers felt the need to have practical and collaborative mentoring linked to classroom experiences. (1)	
2	*"So based on my experiences, a school should develop structured mentoring and professional development program specifically focused on NGSS implementation."*	The suggestion was put forth that the school have a structured mentoring program and professional development program devoted to NGSS. (2)	
2	*"Beginning teachers and even experienced educators need continuous guidance in applying inquiry-based instruction, performance-based, and three-dimensional learnings."*	Continuous guidance was needed by both beginning and experienced teachers in inquiry, performance-based instruction, and three-dimensional learning. (2)	
3	*"For me, maybe teachers need sustained, practical, and collaborative mentoring programs rather than one-time seminars or theoretical trainings."*	They preferred sustained, practical and collaborative mentoring and training instead of one-time and theory-based. (3)	
4	*"I think one, we should all start with making the teachers more deeper on NGSS."*	There was an initial mentoring priority to improve teachers' knowledge of NGSS. (4)	
4	*"Mentoring. I think it should be an active mentoring."*	Active mentoring was found to be a suitable support mechanism for NGSS implementation. (4)	
5	*"Another is a series of trainings and orientations, how we could make this even more better."*	A series of training and orientation was suggested to enhance NGSS implementation. (5)	
5	*"And at the same time, we teachers also would like to have more trainings on this to enhance the knowledge and also the experiences that we supposed to show to our students."*	More training was required to enhance teachers' knowledge and classroom practices with students. (5)	
6	*"The teachers need sustained hands-on mentoring, not one-day workshops where we sit and prepare plans, but should be more on allowing a classroom modeling, co-planning sessions, consistent, that should be consistent, and feedback cycles."*	One-day workshops were not desired, hands-on mentoring through classroom modelling, co-planning and feedback cycles was preferred. (6)	
7	*"I think schools should establish structured mentoring programs that include peer coaching, collaborative lesson planning, and regular professional development."*	Mentoring, using peer coaching, collaborative planning, and ongoing professional development was suggested for schools. (7)	
8	*"Personally, based on my experiences, teachers need practical mentoring."*	Teachers needed practical mentoring when using NGSS. (8)	
9	*"Teachers need practical mentoring focused on lesson implementation. Also, classroom management during inquiry activities and assessment strategies."*	There was a need for practical mentoring to implement lessons, management of the inquiry classroom, and assessment strategies. (9)	
10	*"I'd say that before actually implementing this NGSS into the classroom, especially if you're new to it, you should familiarize yourselves with the material, especially with the books, since most of the time they're actually inclined with the NGSS three-dimensional framework as well."*	There was a need for familiarity with NGSS-aligned materials prior to classroom implementation, especially for new teachers. (10)	
10	*"And also, I think seminars and more familiarity with the framework is a must."*	There was a need for seminars and for more awareness of the NGSS framework. (10)	
10	*"So teachers, I think they need continuous and practical mentoring that actually focuses on actual classroom implementation of NGSS strategies rather than just the theory itself."*	It was desirable to provide continuous and practical classroom-based mentoring rather than purely theoretical instruction. (10)	Collaborative Coaching, Reflection, and Professional Growth
1	*"This includes peer mentoring, classroom observations with constructive feedback, collaborative lesson planning, workshops that focus on real teaching challenges, and effective NGSS strategies."*	The following mentoring mechanisms were identified as needed: peer mentoring, observations, feedback, collaborative planning, and classroom-based workshops. (1)	
1	*"Mentoring promotes continuous professional growth by encouraging teachers to at least*	The mentoring was seen as a mechanism that facilitated professional	

	reflect on their teaching practices, and somehow share best practices or strategies, and receive constructive feedback, and continuously improve their instructional approaches."	development through reflection, exchange of best practices, constructive feedback, and ongoing development in teaching. (1)	
2	*"Experienced mentors can provide constructive feedback on lesson planning, classroom facilitation, assessment method, and student engagement strategies."*	It should be expected that experienced mentors can give feedback on planning, facilitation, assessment and student involvement. (2)	
2	*"Okay, so it can encourage teacher to become more motivated and sustain their passion and commitment."*	Mentoring was perceived to motivate, inspire and engage teachers. (2)	
3	*"Effective mentoring should provide opportunities for classroom observation, lesson demonstration, coaching, peer reflection, and collaborative planning."*	Effective mentoring opportunities were found to be classroom observation, demonstration lessons, coaching, peer reflection and collaborative planning. (3)	
3	*"Not only focus on content knowledge, but also on pedagogical skills, emotional support, and reflective practices."*	Mentoring had to focus on pedagogical competency as well as content knowledge and emotional support and reflective practice. (3)	
3	*"A supportive mentoring culture empowers teachers to innovate, reflect, and remain committed to meaningful science education."*	A supportive mentoring culture was seen as leading to the enhancement of innovation, reflection and engagement in meaningful science education. (3)	
4	*"But the mentee also has an active, how do you call this, active, he is actively providing ideas or she is actively providing ideas to the mentors and they work together."*	Mentoring was perceived as a two-way street, where mentors and mentees exchanged ideas and co-created. (4)	
5	*"So if there will be proper mentoring, if there will be proper procedure that should be implemented along with the teachers, then it will help the teachers perform well when it comes to the delivery of the program."*	Teachers' self-confidence and the delivery of programs were seen as strengthened through the proper mentoring and procedures. (5)	
6	*"So, those who are experienced in the NGSS should mentor new teachers to unpack their standards and build their confidence in facilitating such programs."*	There was a need for NGSS teachers who were experienced in how to teach NGSS and who could help other teachers get more comfortable with facilitation. (6)	
6	*"Well, we need, as I mentioned a while ago, we need a mentoring framework, so the side-by-side coaching, so we can model out lessons and give more opportunities to observe NGSS-aligned classrooms."*	Mentoring strategies were suggested to be side-by-side coaching, lesson modelling, and observation of NGSS aligned classrooms. (6)	
6	*"Well, from my experience, it creates more a culture of reflection, since we learn on both ends."*	Mentoring was seen as establishing a culture of reflection and learning from each other. (6)	
7	*"Teachers need mentoring that provides practical classroom strategies, feedback, and opportunities for collaborative reflection."*	The required mentoring supports were identified as practical strategies, feedback and shared reflection. (7)	
7	*"Of course, mentoring encourages continuous learning, reflective practices, and collaboration among teachers."*	Mentoring was seen as facilitating ongoing learning, reflective practice and collaboration among teachers. (7)	
8	*"As teachers, of course, everyone will benefit from coaching, so peer mentoring, seminars, demonstration teachings or demonstration lessons, that, of course, give focus on the practices and approaches of NGSS."*	As supports to NGSS practice, coaching, peer mentoring, seminars, and demonstration lessons were identified. (8)	
8	*"Mentoring will really be beneficial to us teachers because it encourages reflection. At the same time, it shares best practices, approach and strategies, so we learn from them and we can track ongoing improvement of these teaching strategies at the same time."*	Mentoring was seen as a process of reflection and exchange of practice and checking on the improvement of instruction. (8)	
9	*"Schools should develop mentoring systems for experienced NGSS teachers, coach newer teachers through lesson planning, classroom observations, and collaborative reflection sessions."*	The experienced NGSS teachers were suggested to coach the newer teachers through planning, observation and reflection. (9)	
9	*"For mentoring, mentoring encourages reflective practice and continuous improvement in instructional strategies."*	Mentoring was seen as a good way to make teachers think further and improve their teaching methods. (9)	
10	*"I think peer coaching will be very important, especially with someone who is already experienced with NGSS, collaborative planning, and sustained professional development programs."*	It was suggested to use peer coaching of experienced NGSS teachers, collaborative planning, and ongoing professional development as framework structures. (10)	
10	*"I think for me, mentoring helps promote my growth by encouraging reflection, collaboration, and the ongoing improvement in teaching practices."*	Mentoring was seen as a way to foster professional development with a focus on reflection, collaboration and further instructional enhancements. (10)	
1	*"That should be developed including inquiry facilitation, critical thinking instruction, curriculum integration, assessment design, classroom management to enhance on activities, and effective integration of science and engineering practices into daily instruction."*	Competencies identified were inquiry facilitation, critical thinking instruction, curriculum integration, assessment design, classroom management, and integration of science and engineering practices. (1)	Development of NGSS Pedagogical and Assessment Competencies
2	*"So mentoring program should also focus in developing competencies like inquiry-based pedagogy, differentiated instruction, classroom management during collaborative activities, scientific communication, reflective teaching, and technology integration."*	Necessary competencies were identified as Inquiry pedagogy, Differentiation, Classroom Management, Scientific Communication, Reflective Teaching, and Technology Integration. (2)	
3	*"I think they need guidance in three-dimensional lessons. Creating performance-based assessment, how to facilitate inquiry, and one of the most important things is how to manage a student-centered classroom."*	Facilitation and support were needed for teachers with regard to three-dimensional lessons, performance-based assessment, facilitation of inquiry, and student-centered approaches to classroom management. (3)	
3	*"For me, competencies that should be developed include inquiry facilitation, we can say scientific argumentation, interdisciplinary integration, assessment literacy."*	Competencies to be developed were found to be inquiry facilitation, scientific argumentation, interdisciplinary integration and assessment literacy. (3)	
5	*"For me, cognitive and emotional competencies can be developed here because most people are using AI, students are using AI that actually tends to discourage students to think deeply, critically, it is because they are relying on the technologies that they can use in the field."*	To overcome the students' dependence on technology, cognitive and emotional skills were required. (5)	
6	*"So, more on designing, competencies to develop. So, more on designing investigations, facilitating discourse, and of course, integrating all the cross-cutting concepts, so we can easily assess the three-dimensional learning that is the main goal of the NGSS."*	Competencies were identified to be designing investigations, facilitating discourse, integrating crosscutting concepts, and assessing three-dimensional learning. (6)	
7	*"Competencies in inquiry facilitation, as well as assessment literacy, classroom management, and integration of technologies should be strengthened."*	The competencies that were identified as needing strengthening were inquiry facilitation, assessment literacy, classroom management, and the integration of technology. (7)	
8	*"Important competencies, of course, this must include inquiry facilitation, lesson integration, assessment design, and, of course, classroom management should be developed as well."*	Competencies that were identified for development included inquiry facilitation, lesson integration, assessment design and classroom management. (8)	
9	*"I think teachers should develop competencies in inquiry facilitation, as well as differentiated instruction, assessment design, and integration of technology."*	Competencies to be developed were inquiry facilitation, differentiated instruction, assessment design, and technology integration. (9)	
10	*"Key competencies that must be developed are lesson planning, inquiry facilitation, especially the kind of questioning that must be thrown to the students, the design of the assessment, and how to integrate the three dimensions of NGSS."*	Competencies identified were lesson planning, inquiry facilitation, questioning, assessment design, and three-dimensional integration. (10)	
3	*"Yes, we can include also technology integration and culturally responsive teaching."*	The integration of technology and culturally responsive teaching were also cited as needed skills. (3)	Technology Integration and Resource Support
4	*"And then the second one, we could also fuse technology inside the classroom for other experiments or simulations or models that we cannot do in the laboratory or inside the classroom."*	The integration of technology was suggested for experiments, simulations and models that were not easy to create physically in class. (4)	
4	*"So I think there should be a 21st century teaching experiences among teachers so that at least trying different applications will not be a hindrance."*	The teachers required 21st century teaching experiences to help them with the use of new applications and technologies. (4)	
1	*"A mentoring framework should include professional learning communities, regular training workshops, instructional coaching, reflective teaching practices, and access to NGSS-aligned instructional resources."*	Important framework structures identified were professional learning communities, workshops, coaching, reflection, and resources aligned with NGSS. (1)	Professional Learning Communities and Institutional Support Structures
2	*"One important mentoring mechanism is the establishment of professional learning communities or the PLCs where science teachers regularly collaborate, share best practices, discuss challenges, and develop instructional materials together."*	Professional learning communities were found to be vehicles for collaboration, sharing practices, discussing problems, and creating content for instruction. (2)	
2	*"A comprehensive mentoring framework should include regular training workshop, peer*	The framework work structures proposed were workshops, peer coaching,	

	coaching, collaborative lesson planning, action research opportunities, reflective sessions, and continuous monitoring and evaluation."	collaborative planning, action research, reflective sessions, monitoring and evaluation sessions. (2)	
3	*"As for me, a sustainable mentoring framework should include continuous feedback mechanisms, demonstration classes. If possible, we can do action research opportunities, coaching cycles, and accessible teaching resources."*	Sustainable framework structures were identified as feedback mechanisms, demonstration classes, action research, coaching cycles and accessible resources. (3)	
5	*"The support when it comes to classroom management, the support when it comes to materials and proper guidance, how these programs can be implemented, administration and management can give us support on this."*	Administrative support was felt to be needed for classroom management, resources and guidance for implementation. (5)	
5	*"For me, proper system could be adopted, the strategies, the process, step-by-step procedures, the proper outlining guidelines and proper framework, how could this NGSS be implemented well inside a classroom."*	There was a need for clear strategy, procedure, guidelines, and framework structures for classroom implementation of NGSS. (5)	
6	*"So, more on professional learning communities for observation schedules, providing more resource banks and sources to support preparations of plans, and of course, more time for collaborative planning."*	Structures proposed to support PL communities were PL communities, observation schedules, resource banks, and collaborative planning time. (6)	
7	*"Mentoring programs should include workshops, peer observations, as well as collaborative meetings, and access to instructional resources."*	Mentoring framework structures were identified to include workshops, peer observations, collaborative meetings, and instructional resources. (7)	
8	*"In building this mentoring framework, we need professional learning communities, also collaborative planning lessons, not only with our peers, at the same time with our heads and the admin, and, of course, regular coaching opportunities must be also included."*	Professional learning communities, peer and administrative collaboration and regular coaching were suggested as structures for the framework. (8)	
9	*"I think for the structures or systems, it's going to be the regular workshops, peer observations as well, collaborative planning meetings, and access to NGSS teaching resources should be included."*	The required framework structures were identified as workshops, peer observations, collaborative planning and NGSS teaching resources. (9)	
4	*"An evaluation system that will also involve in NGSS. So that at least you can be able to improve whatever is lacking in your teaching or something like that."*	An evaluation system was proposed on NGSS which could be used to find the gaps in teaching practice and enhance them. (4)	Monitoring, Evaluation, and Research-Based Improvement
4	*"Another thing is that because the teacher is the one who will execute it, there should be a series also of action researches or something like that."*	The use of action research was suggested as a way for teachers to study and enhance NGSS practices. (4)	
8	*"That, of course, would focus on classroom application, the collaboration, and continuous feedback, just to make sure that the effectivity and the success rate of NGSS will be monitored and evaluated in real time."*	Mentoring emphases were thought to be important for classroom application, collaboration, continuous feedback and real-time monitoring. (8)	

Organization of Formulated Meanings into Theme Clusters Relevant to Corollary Question 4

The formulated meanings were organized into six theme clusters: Sustained and Practical Classroom-Based Mentoring; Collaborative Coaching, Reflection, and Professional Growth; Development of NGSS Pedagogical and Assessment Competencies; Technology Integration and Resource Support; Professional Learning Communities and Institutional Support Structures; and Monitoring, Evaluation, and Research-Based Improvement. These clusters formed the basis of the Proposed Enhancement Mentoring Framework for Filipino science teachers using the NGSS.

Sustained and Practical Classroom-Based Mentoring

Participants emphasized that NGSS mentoring should be continuous, practical, collaborative, and classroom-focused rather than limited to one-time seminars. They identified classroom modeling, co-planning, feedback cycles, inquiry facilitation, assessment, and three-dimensional lesson implementation as important components of sustained mentoring.

Collaborative Coaching, Reflection, and Professional Growth

Participants viewed mentoring as an active process involving coaching, classroom observation, constructive feedback, collaborative planning, peer reflection, and professional learning. Side-by-side coaching and shared professional experiences were seen as valuable for refining instructional practices and supporting continuing professional growth.

Development of NGSS Pedagogical and Assessment Competencies

Participants identified inquiry facilitation, questioning strategies, three-dimensional lesson planning, performance-based assessment, classroom management, differentiated instruction, scientific communication, and technology integration as competencies requiring further development. The findings indicate that mentoring should strengthen teachers' ability to translate NGSS principles into effective classroom instruction and assessment.

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Technology Integration and Resource Support

Technology and instructional resources were identified as important supports for simulations, modeling, inquiry, and other learning experiences, particularly when laboratory resources were limited. Participants also emphasized the need for appropriate guidance in using technology meaningfully to promote critical thinking and active learning.

Professional Learning Communities and Institutional Support Structures

Participants emphasized professional learning communities, collaborative planning, workshops, coaching, resource banks, and administrative support as essential structures for sustaining NGSS implementation. These mechanisms provide opportunities to share practices, address challenges, develop instructional resources, and strengthen collective professional capacity.

Monitoring, Evaluation, and Research-Based Improvement

Monitoring, evaluation, feedback, reflection, and action research were identified as mechanisms for continuous improvement. Participants emphasized the importance of regularly examining classroom implementation, providing feedback, and using evidence to identify areas for improvement in NGSS teaching practices.

Emergent Theme Relevant to Corollary Question 4: Developing a Sustained, Practice-Based, and Collaborative Proposed Enhancement Mentoring Framework for NGSS Implementation.

The six themes converged into the emergent theme Developing a Sustained, Practice-Based, and Collaborative Proposed Enhancement Mentoring Framework for NGSS Implementation. Participants described the framework as needing to be continuous, practical, collaborative, classroom-based, competency-driven, resource-supported, institutionally structured, and continually evaluated.

The proposed framework should extend beyond one-time training by incorporating classroom observation, demonstration lessons, mentor–mentee feedback, peer reflection, co-planning, professional learning communities, and access to NGSS-aligned resources. It should also strengthen teachers’ competencies in lesson planning, questioning, three-dimensional integration, assessment, classroom management, technology use, and reflective practice.

Overall, the findings indicate that effective NGSS implementation requires interconnected professional and institutional support. Professional learning communities, administrative support, mentoring, observation schedules, resource banks, action research, monitoring, evaluation, and feedback can provide a sustained structure for improving practice. Thus, the proposed framework should remain grounded in actual classroom experiences and teachers’ professional needs to support meaningful, confident, and sustained NGSS implementation.

5. Conclusions

The results of the interviews and interactions with the participants help to answer the main research question and corollary questions and are summarized here:

1. In response to the central question, Filipino science teachers described an embodied experience of implementing NGSS as a transformation in their science teaching. NGSS shifted its focus from a content delivery approach to one centered on inquiry, hands-on, real-world, phenomenon-based, and student-centered science learning. This shift in teaching and learning styles and approaches was incarnated due to the physical shifts, emotional changes, cognitive adjustments, and reconstruction of identity required for this transformation. The teachers became 'facilitators' of scientific inquiry, leading students in science questions, investigations, collaboration, explanation, and linking science to real-life.
2. In relation to Corollary Question 1, the participants described the implementation of NGSS three-dimensional learning as instructionally demanding. Integrating disciplinary core ideas, science and engineering practices, and crosscutting concepts within limited class time was particularly challenging. They also raised concerns about students' readiness for inquiry, assessment alignment, limited laboratory and instructional materials, and the need for deeper content understanding. In response, teachers adjusted their practices through scaffolding, differentiated instruction, guided inquiry, collaborative learning, reflective planning, and continued support. These experiences indicated that NGSS implementation required both adaptive teaching and sustained professional support.
3. In relation to Corollary Question 2, the meanings derived from the participants' accounts indicated that NGSS implementation reshaped their understanding of science teaching. Science was experienced less as the transmission of information and more as a process involving questioning, investigation, reasoning, application, and meaning-making. This shift also influenced their professional roles. Rather than functioning primarily as lecturers or content providers, the teachers described themselves as facilitators,

mentors, coaches, co-investigators, and learning partners who supported students throughout the learning process. NGSS therefore placed greater emphasis on purposeful science learning that developed curiosity, critical thinking, problem-solving, scientific literacy, and connections between classroom learning and real-life contexts.

4. For corollary question 3, the themes that emerged from the formulated meanings indicated that meaningful implementation of the NGSS required student engagement, teacher adaptation of the NGSS, collaboration, and ongoing support in the face of persistent constraints. The participants concluded that NGSS is successful when the students are active in their learning, involved in phenomena-based learning, real-world problem-solving, hands-on activities, collaborative tasks, and evidence-based learning. But factors such as time, materials, technology, workload, assessment requirements, and student readiness continued to impact implementation. The findings indicate that effective NGSS learning was not solely the responsibility of the individual teacher but also relied on co-teaching, administrative support, professional learning communities, and adaptive assessment.

5. With corollary question 4 confirmed, the evolution of a sustained, practice-based, and collaborative Proposed Enhancement Mentoring Framework for implementing the NGSS is underway. The participants stressed the need for ongoing, hands-on mentoring rather than a seminar or theoretical training. Incorporate the following elements in the proposed framework: classroom observation, lesson demonstration, peer coaching, collaborative planning, constructive feedback, reflection, technology integration, resource support, assessment development, professional learning communities, and monitoring and evaluation. As such, the Proposed Enhancement Mentoring Framework is helpful and practical and can enhance teachers' confidence, competency, and Preparedness in implementing NGSS in a meaningful and sustainable manner.

6. Recommendations For Further Inquiry

1. Investigation of NGSS implementation in other school contexts. In future research, it would be interesting to examine the 'embodied experiences' of science teachers who adopt the NGSS in international schools, local schools, and other educational contexts. The findings of this inquiry may help identify whether the transformation of science teachers observed in this study is also found among science teachers from other nationalities, school systems, grades, and science subjects.
2. Longitudinal Study on Teachers' Adaptation to Three-Dimensional Learning. A future study could take a longitudinal perspective to examine how science teachers make incremental changes as they learn to integrate the disciplinary core ideas, science and engineering practices, and crosscutting concepts over time. This can provide greater insights into teachers' confidence, competence, and instructional flexibility when implementing NGSS in classrooms.
3. Inquiry-Based and Life-Relevant Science Learning Experiences of Students. In the future, it would be interesting to explore how students respond to NGSS-based instruction, particularly regarding inquiry, collaboration, real-world, evidence-based explanations, and scientific literacy. This kind of research complements current research by giving learners' voices on the impact of NGSS on their involvement in, comprehension of, and appreciation for science.
4. Future research could examine how school-level conditions influence sustained NGSS implementation. Attention could be given to administrative support, mentoring, peer collaboration, professional learning communities, and access to instructional resources. Such studies may help identify institutional structures and practices that enable teachers to sustain meaningful NGSS instruction despite constraints involving instructional time, available materials, workload, and assessment.

5. Review of the proposed Enhancement Mentoring Framework for the implementation of NGSS. Future research can evaluate the effectiveness, applicability, and impact of the Proposed Enhancement Mentoring Framework in a real school context. This can involve investigating the impact of classroom observation, peer coaching, lesson demonstration, co-planning, feedback and reflection, technology integration and monitoring, and on teachers' NGSS pedagogical competence, confidence, and classroom practice.

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An example appendix