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# Exploring Science Teachers' Experiences on the Spiral Progression Approach in Junior High School Science Education

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**Abstract:** The Spiral Progression Approach (SPA) serves as a foundational framework of the Philippine K to 12 Science Curriculum, requiring learners to revisit scientific concepts with increasing complexity across grade levels. Despite its intended benefits, science teachers continue to encounter implementation challenges that influence curriculum delivery and learner outcomes. This study explored the lived experiences of Junior High School science teachers in implementing the Spiral Progression Approach. Specifically, it examined the pedagogical practices employed to facilitate continuity of learning, identified issues and challenges encountered in implementation, and developed a framework grounded in teachers' experiences. Using a descriptive qualitative research design, the study involved fifteen Junior High School science teachers from the District of Taal, Batangas during School Year 2025–2026. Data were gathered through semi-structured interviews, focus group discussions, and document analysis and were analyzed using thematic analysis. Findings revealed four major themes: Deepening Conceptual Understanding Over Time, Facilitating Learning Through Inquiry and Engagement, Adapting Instruction to Diverse Learners, and Navigating Implementation Challenges. Teachers employed scaffolding, contextualization, differentiated instruction, inquiry-based learning, and reflective assessment to sustain conceptual continuity. However, curriculum congestion, specialization mismatch, inadequate resources, limited laboratory facilities, and varying learner readiness remained persistent challenges. The study proposes a Spiral Progression Enhancement Framework emphasizing recursive conceptual learning, instructional adaptation, contextual integration, inquiry-based instruction, reflective assessment, and institutional support. Findings highlight the importance of coherent pedagogical practices and sustained support mechanisms in ensuring effective implementation of the Spiral Progression Approach.

**Keywords:** Spiral Progression Approach; Science education; K to 12 curriculum; Science teachers; Qualitative research; Curriculum implementation

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## 1. Introduction

Educational reform remains a central strategy for improving the quality, relevance, and responsiveness of educational systems worldwide. Across different countries, curriculum innovations have been introduced to address emerging societal demands, technological advancements, and evolving expectations for learner competencies. Within science education, curriculum reforms have increasingly emphasized conceptual coherence, inquiry-based learning, interdisciplinary integration, and the development of scientific literacy necessary for participation in contemporary society. These reforms recognize that scientific understanding develops progressively and that effective science learning requires sustained opportunities for learners to revisit and deepen conceptual knowledge over time.

In the Philippines, one of the most significant educational reforms in recent decades was the implementation of the K to 12 Basic Education Program through Republic Act No. 10533. The reform extended basic education and introduced substantial changes in curriculum design, content organization, instructional delivery, and assessment practices. Among its major innovations was the adoption of the Spiral Progression Approach (SPA) in science education. Unlike the previous discipline-based curriculum, wherein Earth Science, Biology, Chemistry, and Physics were taught separately at specific grade levels, SPA integrates all major science disciplines across Grades 7 to 10 and revisits concepts with increasing complexity and sophistication. The approach is anchored on the premise that repeated encounters with scientific concepts promote conceptual retention, deeper understanding, and meaningful knowledge construction.

The theoretical foundation of SPA can be traced to Bruner's Spiral Curriculum Theory, which posits that any subject can be taught effectively at any developmental stage provided that concepts are revisited and reconstructed according to learners' cognitive growth. Bruner argued that learning is not a linear accumulation of information but a recursive process through which understanding becomes increasingly refined through repeated exposure and application. In science education, such progression is particularly important because many scientific concepts require gradual abstraction and increasing levels of cognitive complexity. Consequently, SPA seeks to ensure continuity of learning while strengthening learners' ability to connect scientific ideas across disciplines and contexts.

The adoption of SPA reflects broader global trends toward integrated science education. International research suggests that integrated curricula promote conceptual coherence, facilitate interdisciplinary thinking, and enable learners to recognize relationships among scientific phenomena. Rather than treating scientific disciplines as isolated domains, integrated approaches encourage learners to view science as an interconnected body of knowledge that can be applied to real-world issues. Through repeated engagement with core scientific ideas, learners are expected to develop stronger analytical skills, scientific reasoning abilities, and problem-solving competencies.

Despite its theoretical strengths and intended benefits, the implementation of SPA has generated substantial debate among educators, researchers, and policymakers. Several studies have reported persistent challenges affecting curriculum delivery under the spiral framework. Among the most frequently cited concerns are curriculum congestion, limited instructional time, inadequate laboratory resources, insufficient professional development opportunities, and teacher specialization mismatch. Because science teachers are often trained in only one discipline, many are required to teach content areas beyond their specialization, potentially affecting instructional confidence and content mastery. These challenges become more pronounced in resource-constrained schools where laboratory facilities, instructional materials, and technological resources remain limited.

The implications of these implementation challenges extend beyond classroom instruction. National and international assessments have consistently highlighted concerns regarding science achievement among Filipino learners. Results from large-scale assessments such as the Programme for International Student Assessment (PISA) and the National Achievement Test (NAT) reveal continuing difficulties in scientific literacy, conceptual understanding, and higher-order thinking skills. While learner performance is influenced by multiple factors, these outcomes have prompted renewed scrutiny of curriculum implementation processes and instructional practices within science education.

Existing scholarship on SPA implementation has largely focused on quantitative measures such as academic achievement, teacher perceptions, curriculum evaluations, and assessment outcomes. Although these studies provide valuable information regarding patterns and trends, they often overlook the lived realities of teachers who serve as primary curriculum implementers. Teachers occupy a critical position within educational reform because they translate curricular intentions into actual learning experiences. Their interpretations, adaptations, decisions, and responses to contextual challenges significantly influence how curriculum reforms are enacted in classrooms. Consequently, understanding teachers' lived experiences offers important insights into the complex interplay between curriculum design, instructional practice, and educational context.

Recent educational research increasingly recognizes the value of exploring teacher experiences to understand curriculum implementation. Teachers' narratives reveal not only the strategies they employ to address instructional challenges but also the beliefs, values, and professional judgments that shape their practice. Through qualitative inquiry, researchers can capture the nuanced ways in which teachers navigate curriculum demands, respond to learner diversity, and negotiate institutional constraints. Such perspectives are particularly relevant in the context of SPA, where successful implementation depends heavily on teachers' ability to facilitate conceptual continuity, inquiry-based learning, and interdisciplinary integration.

Within the Philippine context, limited qualitative studies have explored how science teachers experience and make sense of the Spiral Progression Approach. Most existing investigations emphasize implementation issues and achievement outcomes without examining the deeper pedagogical and professional experiences of teachers. As a result, there remains a significant gap in understanding how science teachers interpret SPA, adapt instructional practices, and manage implementation challenges in everyday classroom settings. Addressing this gap is important for informing responsive teacher development programs, curriculum enhancement initiatives, and evidence-based educational policies.

Grounded in these considerations, this study explored the lived experiences of Junior High School science teachers in implementing the Spiral Progression Approach under the Philippine K to 12 Curriculum. Specifically, it examined the pedagogical practices employed to facilitate the progression of science competencies across grade levels, identified the issues and challenges encountered in curriculum implementation, and developed a framework grounded in teachers' experiences and insights. By documenting the voices and experiences of science teachers, the study contributes to a deeper understanding of curriculum implementation and offers implications for strengthening science education in the Philippines.

## 2. Research questions

This study sought to answer the following questions:

How do Junior High School science teachers experience the implementation of the Spiral Progression Approach?

What pedagogical practices facilitate the seamless progression of science competencies across grade levels?

What issues and challenges do science teachers encounter in implementing the Spiral Progression Approach?

What framework may be developed based on teachers' experiences and insights?

## 3. Significance of the study

The study contributes to science education by providing an in-depth understanding of how science teachers navigate the complexities of implementing SPA. Findings may inform teacher professional development programs, curriculum enhancement initiatives, instructional resource development, and policy formulation. Moreover, the proposed framework may serve as a guide for educators, school leaders, and curriculum implementers seeking to strengthen science instruction under the K to 12 curriculum.

## 4. Scope and limitations

The study focused on Junior High School science teachers implementing the Spiral Progression Approach in the District of Taal, Batangas during School Year 2025–2026. Fifteen participants with five to fifteen years of teaching experience were purposively selected. The findings are limited to the experiences and perceptions of the participants and may not represent all science teachers across the Philippines. The study concentrated solely on Junior High School science instruction and did not include other grade levels or subject areas.

## 5. Literature review

### 5.1. The Spiral Progression Approach in science education

The Spiral Progression Approach (SPA) emerged as one of the most significant curriculum reforms introduced under the Philippine K to 12 Basic Education Program. Anchored on Spiral Curriculum Theory, the approach is founded on the principle that learners develop deeper understanding when concepts are revisited repeatedly at increasing levels of complexity [1]. Rather than teaching scientific disciplines in isolation, SPA integrates Biology, Chemistry, Physics, and Earth Science across grade levels, allowing learners to encounter and reconstruct scientific concepts progressively. This curricular organization seeks to strengthen conceptual continuity, improve retention, and facilitate meaningful connections among scientific ideas.

Globally, spiral curricula have been recognized as effective mechanisms for promoting long-term conceptual development. Spiral curricula enable learners to revisit knowledge structures repeatedly, thereby facilitating reinforcement, consolidation, and cognitive refinement [2]. Through recursive exposure, learners are afforded opportunities to deepen understanding while connecting prior knowledge with new information. Such progression is particularly important in science education, where concepts often require gradual abstraction and increasing cognitive sophistication.

Research suggests that integrated and spiral curricula contribute to the development of scientific literacy and higher-order thinking skills. By repeatedly engaging learners with interconnected concepts, SPA encourages analytical reasoning, transfer of learning, and interdisciplinary understanding. Studies conducted in various educational contexts have shown that students exposed to recursive learning experiences demonstrate stronger conceptual retention and improved ability to apply scientific principles in unfamiliar situations. These findings support the theoretical assumption that learning becomes more meaningful when knowledge is revisited and expanded rather than taught as isolated units.

Within the Philippine educational system, SPA was adopted to address concerns regarding fragmented science instruction and limited opportunities for interdisciplinary learning. Prior to the implementation of the K to 12 curriculum, science subjects were organized according to disciplinary boundaries, often resulting in compartmentalized understanding of scientific concepts. Through SPA, curriculum designers envisioned a more coherent science curriculum that promotes conceptual progression and continuity from Grade 7 to Grade 10. The integration of disciplines was intended to help learners recognize relationships among scientific phenomena while gradually developing scientific competence.

Despite these intended benefits, the implementation of SPA has generated mixed responses among educators. While some studies report positive outcomes related to conceptual understanding and learner engagement, others have documented persistent challenges affecting curriculum delivery. These divergent findings suggest that the effectiveness of SPA depends largely on instructional practices, teacher preparedness, contextual factors, and institutional support systems. Consequently, understanding how teachers experience and implement the approach remains essential for evaluating its effectiveness and sustainability.

## 5.2. Pedagogical practices supporting spiral progression

Effective implementation of SPA relies heavily on pedagogical practices that facilitate conceptual continuity and progressive learning. Because learners are expected to revisit scientific concepts at increasing levels of complexity, teachers must employ instructional strategies that connect prior learning with new competencies. Literature consistently identifies inquiry-based instruction, scaffolding, contextualization, differentiated instruction, and formative assessment as key pedagogical approaches supporting successful implementation of spiral curricula.

Inquiry-based learning is widely regarded as a cornerstone of effective science instruction. According to Aldossari (2018), inquiry-based approaches engage learners in questioning, investigating, experimenting, and constructing explanations based on evidence [3]. Rather than serving as passive recipients of information, students become active participants in the learning process. Inquiry-based instruction aligns closely with the principles of SPA because it encourages learners to revisit concepts through exploration and application, thereby deepening understanding over time. Darling-Hammond et al. (2017) similarly emphasized that active learning experiences foster higher levels of engagement, conceptual understanding, and critical thinking [4].

Scaffolding represents another essential pedagogical practice within spiral curricula. Grounded in Vygotskian perspectives of learning, scaffolding involves providing temporary support structures that enable learners to accomplish tasks beyond their current level of competence. As learners gain proficiency, instructional support is gradually withdrawn, allowing them to assume greater responsibility for learning. Within SPA, scaffolding facilitates continuity by helping learners connect previously acquired knowledge with increasingly sophisticated concepts. Teachers play a crucial role in identifying learners' prior understandings and designing instructional experiences that build upon existing cognitive structures.

Differentiated instruction likewise contributes significantly to effective curriculum implementation. Learners vary in terms of readiness, learning preferences, interests, and academic backgrounds. Consequently, uniform instructional approaches may not adequately address diverse learning needs. Tomlinson (2017) argued that differentiated instruction enables teachers to modify content, processes, products, and learning environments to maximize learner engagement and achievement [5]. Within the context of SPA, differentiation becomes particularly important because learners encounter recurring concepts at varying levels of complexity. Flexible instructional approaches allow teachers to accommodate diverse learner needs while maintaining curriculum progression.

Contextualization has also emerged as a critical component of effective science teaching. Educational scholars emphasize that learning becomes more meaningful when concepts are connected to learners' lived experiences and sociocultural contexts. Contextualized instruction enables students to relate abstract scientific concepts to real-world situations, thereby increasing engagement and relevance. UNESCO (2022) highlighted the importance of culturally responsive and localized instructional approaches in promoting meaningful learning across diverse educational settings [6]. Within SPA, contextualization serves as a bridge between conceptual understanding and practical application, helping learners appreciate the relevance of science in everyday life.

Assessment practices within spiral curricula similarly require careful consideration. Traditional assessment approaches often focus on discrete content mastery rather than conceptual progression. However, the recursive nature of SPA necessitates assessment strategies that capture cumulative learning and conceptual development over time. Formative assessments, reflective tasks, performance-based activities, and authentic assessments provide opportunities for teachers to monitor learner progress while identifying misconceptions and instructional needs. Such approaches align with contemporary views of assessment as an integral component of learning rather than merely a mechanism for evaluating outcomes.

Collectively, these pedagogical practices demonstrate the complex instructional demands associated with SPA implementation. Teachers are required not only to deliver content but also to facilitate conceptual continuity, accommodate learner diversity, promote inquiry, and assess cumulative understanding. These responsibilities highlight the central role of teachers in translating curricular intentions into meaningful learning experiences.

## 5.3. Challenges in implementing the Spiral Progression Approach

Although SPA offers substantial pedagogical and curricular advantages, numerous studies have documented implementation challenges affecting its effectiveness. These challenges often arise from structural, instructional, and contextual factors that influence curriculum delivery. Among the most frequently reported concerns are curriculum congestion, teacher specialization mismatch, inadequate instructional resources, limited laboratory facilities, and insufficient professional development opportunities.

Curriculum congestion remains one of the most widely discussed issues associated with SPA implementation. The integration of multiple science disciplines within a single academic year requires teachers to cover a broad range of competencies within limited instructional time. Oducado (2021) observed that teachers frequently struggle to balance curriculum coverage with conceptual depth [7]. The pressure to complete prescribed competencies often results in accelerated pacing and superficial treatment of concepts.

Consequently, opportunities for inquiry-based learning, experimentation, and conceptual exploration may be reduced.

Teacher specialization mismatch represents another significant challenge. Many science teachers possess academic preparation in only one discipline, such as Biology, Chemistry, Physics, or Earth Science. However, SPA requires teachers to teach content across all major scientific disciplines regardless of specialization. Research indicates that teaching outside one's area of expertise may affect instructional confidence, content mastery, and pedagogical effectiveness. Orbe et al. (2018) found that teachers assigned to disciplines beyond their specialization often experience increased preparation demands and professional anxiety [8]. Similar findings have been reported in other studies examining integrated science instruction.

Resource limitations further complicate curriculum implementation. Effective science instruction frequently depends on access to laboratory facilities, instructional materials, technological tools, and science equipment. Unfortunately, many public schools continue to experience shortages in these areas. Danao and Malana (2023) emphasized that inadequate laboratory resources constrain opportunities for experiential and inquiry-based learning [9]. Without access to appropriate materials, teachers may be forced to rely heavily on lecture-based instruction, thereby limiting learners' engagement in scientific practices.

Professional development has likewise emerged as a critical concern. Although curriculum reforms often introduce new instructional expectations, teacher training programs do not always provide sufficient preparation for implementation. Batomalaque (2017) argued that one-time workshops and generalized training programs are insufficient for addressing the complexities associated with integrated science instruction [10]. Teachers require sustained professional learning opportunities that focus on content knowledge, pedagogical strategies, curriculum integration, and assessment practices. Continuous support becomes particularly important in contexts where teachers are expected to teach multiple disciplines.

Learner-related challenges also influence SPA implementation. Students enter classrooms with varying levels of prior knowledge, academic preparedness, and learning readiness. Because SPA assumes continuity of learning across grade levels, gaps in prior understanding may hinder learners' ability to engage successfully with increasingly complex concepts. Teachers therefore face the challenge of addressing learning gaps while simultaneously maintaining curriculum progression. This tension often requires substantial instructional adaptation and differentiation.

Beyond instructional challenges, broader systemic factors influence curriculum implementation. School leadership, policy support, resource allocation, and organizational culture shape the conditions under which teachers operate. Educational reforms may encounter difficulties when institutional structures fail to provide adequate support mechanisms. Consequently, successful implementation of SPA requires coordinated efforts among teachers, school leaders, curriculum specialists, and policymakers.

The literature consistently suggests that implementation challenges are not merely technical problems but manifestations of broader educational realities. Understanding how teachers navigate these realities is therefore essential for developing responsive support systems and sustainable improvement initiatives.

## 6. Research design

This study employed a qualitative descriptive research design to explore and understand the lived experiences of Junior High School science teachers in implementing the Spiral Progression Approach (SPA) under the

Philippine K to 12 Curriculum. Qualitative research is particularly appropriate when the objective is to examine how individuals interpret, describe, and make meaning of their experiences within specific social and professional contexts [11]. The descriptive qualitative approach enabled the researcher to capture rich and detailed accounts of teachers' experiences, instructional practices, challenges, and adaptive strategies associated with SPA implementation.

The study was guided by a constructivist perspective, which assumes that knowledge and meaning are socially constructed through human experiences and interactions. This perspective aligns with the nature of the inquiry, as it seeks to understand how science teachers interpret curriculum implementation within the realities of their classroom environments. Through qualitative exploration, the study generated contextualized insights into how teachers facilitate conceptual continuity, respond to instructional demands, and navigate challenges associated with the Spiral Progression Approach.

Furthermore, the study adopted a thematic approach to qualitative inquiry. Thematic analysis provided a systematic process for identifying recurring patterns, categories, and themes emerging from participants' narratives. This methodological orientation allowed the researcher to move beyond individual experiences and identify broader patterns that characterize the implementation of SPA in Junior High School science education.

## 6.1. Research locale and participants

The study was conducted in selected public secondary schools within the District of Taal, Division of Batangas Province, Philippines, during the School Year 2025–2026. The locale was chosen because it provided a relevant context for examining the implementation of the Spiral Progression Approach among science teachers who have extensive experience teaching under the K to 12 Curriculum.

Participants were selected through purposive sampling, a non-probability sampling technique commonly employed in qualitative research to identify information-rich cases that can provide meaningful insights into the phenomenon under investigation [12]. The inclusion criteria required participants to: (1) be currently teaching Junior High School Science; (2) have at least five years of teaching experience under the K to 12 Curriculum; and (3) possess direct experience in implementing the Spiral Progression Approach.

A total of fifteen (15) Junior High School science teachers participated in the study. Ten (10) participants were involved in individual semi-structured interviews, while five (5) additional participants participated in a Focus Group Discussion (FGD). The combination of individual interviews and group discussions provided opportunities for both personal reflection and collaborative sharing of experiences, thereby enriching the depth and breadth of the data collected.

## 6.2. Research instrument

The primary instrument used in the study was a researcher-developed semi-structured interview guide. The interview protocol was designed based on the objectives of the study and relevant literature on curriculum implementation, science pedagogy, and the Spiral Progression Approach. The guide consisted of open-ended questions that encouraged participants to describe their experiences, instructional practices, challenges, coping mechanisms, and recommendations related to SPA implementation.

To ensure content validity, the interview guide underwent expert review by specialists in science education, curriculum studies, and qualitative research. Suggestions provided by the validators were incorporated to improve clarity, relevance, and alignment with the study objectives. A pilot interview was also conducted with a science teacher who met the inclusion criteria but was not included among the actual participants. Feedback from the pilot interview contributed to refining the wording and sequencing of interview questions.

In addition to the interview guide, a Focus Group Discussion protocol was developed to facilitate collaborative reflection among participants. Document analysis was likewise conducted to triangulate data obtained from interviews and discussions. Relevant curriculum documents, instructional materials, lesson plans, and policy guidelines related to the implementation of SPA were examined to provide contextual understanding and corroborate emerging findings.

## 7. Data collection

Prior to data collection, approval to conduct the study was secured from the appropriate educational authorities and school administrators. Ethical clearance was likewise obtained to ensure compliance with established standards for research involving human participants.

Potential participants were identified through coordination with school administrators and science department coordinators. Eligible participants received formal invitations explaining the purpose of the study, voluntary nature of participation, and procedures for ensuring confidentiality and anonymity. Participants who agreed to participate signed informed consent forms before data collection commenced.

Semi-structured interviews were conducted individually at mutually convenient schedules and venues. Each interview lasted approximately 45 to 60 minutes and was audio-recorded with participants' permission. The interviews focused on teachers' experiences in implementing SPA, instructional strategies employed, perceived benefits, encountered challenges, and suggestions for improvement.

Following the individual interviews, a Focus Group Discussion was conducted with five participants. The discussion lasted approximately 90 minutes and provided opportunities for participants to collectively reflect on common experiences, challenges, and best practices related to SPA implementation. The FGD also served as a mechanism for validating and enriching themes that emerged from the individual interviews.

Document analysis was conducted concurrently with interviews and discussions. Relevant curriculum guides, instructional materials, lesson plans, assessment tools, and school documents were examined to provide contextual support and triangulation for participant narratives.

All interviews and discussions were transcribed verbatim immediately after data collection. The transcripts were reviewed multiple times to ensure accuracy and completeness prior to analysis.

## 8. Data analysis

Data were analyzed using thematic analysis following the framework proposed by Braun and Clarke (2021) [13]. Thematic analysis was selected because of its flexibility and effectiveness in identifying patterns and meanings across qualitative datasets. The analysis followed six interconnected phases.

The first phase involved familiarization with the data. The researcher repeatedly read interview transcripts, focus group discussion records, and documentary evidence to gain a comprehensive understanding of the participants' experiences and perspectives.

The second phase involved generating initial codes. Meaningful statements, phrases, and segments relevant to the research questions were systematically identified and coded. Coding was conducted inductively to allow themes to emerge naturally from the data rather than imposing predetermined categories.

The third phase involved searching for themes. Related codes were clustered into broader categories representing recurring patterns and shared experiences among participants. Emerging themes were continuously compared and refined throughout the analytical process.

The fourth phase focused on reviewing and refining themes. The researcher examined the coherence, consistency, and distinctiveness of each theme to ensure that it accurately represented the underlying data. Redundant or overlapping themes were merged, while themes lacking sufficient supporting evidence were reconsidered.

The fifth phase involved defining and naming themes. Each theme was carefully described, interpreted, and linked to relevant literature and theoretical perspectives. This process facilitated deeper understanding of the meanings embedded within participants' narratives.

The final phase involved producing the analytical narrative. Themes were organized according to the study objectives and supported by representative participant statements. Interpretations were contextualized within existing literature to highlight similarities, differences, and contributions to knowledge regarding SPA implementation.

Ethical Considerations: Ethical principles were observed throughout the conduct of the study. Participation was voluntary, and participants were informed of their right to withdraw from the study at any stage without penalty. Informed consent was obtained prior to data collection, and confidentiality was maintained through the use of pseudonyms and coded identifiers.

All audio recordings, transcripts, and research documents were stored securely and were accessible only to the researcher. Personal information was excluded from research reports to protect participants' identities. Furthermore, the study adhered to the principles of respect for persons, beneficence, and justice, ensuring that participants' rights, welfare, and dignity were safeguarded throughout the research process.

## 9. Discussion

The findings of the study are presented according to the research objectives and are supported by evidence derived from semi-structured interviews, focus group discussions, and document analysis. The thematic analysis revealed recurring patterns that illuminate how Junior High School science teachers experience the implementation of the Spiral Progression Approach (SPA), the pedagogical practices they employ to facilitate curriculum progression, and the challenges they encounter in delivering science instruction. Three overarching thematic clusters emerged from the data: (1) Deepening Conceptual Understanding Through Progressive Learning, (2) Promoting Inquiry, Engagement, and Learner-Centered Practices, and (3) Navigating Instructional Challenges and Adaptive Teaching Practices. These themes collectively demonstrate how science teachers transform SPA from a curricular mandate into a dynamic instructional process that promotes continuity, conceptual growth, and scientific literacy.

### 9.1. Deepening conceptual understanding through progressive learning

One of the most dominant themes that emerged from the participants' narratives was the deliberate effort to deepen students' conceptual understanding through repeated and progressively complex encounters with scientific concepts. Teachers viewed SPA as a structured mechanism that enables learners to build new knowledge upon previously acquired understanding, thereby promoting continuity and cumulative learning. Rather than treating science concepts as isolated topics, participants described instruction as a process of connecting prior knowledge with increasingly sophisticated ideas. This finding reflects the central principle of Bruner's Spiral Curriculum Theory, which posits that learning occurs most effectively when concepts are revisited and reconstructed over time.

Teachers consistently emphasized the importance of revisiting key scientific concepts. Participants reported that review sessions, bridging activities, concept mapping, and recall exercises were routinely integrated into instruction to help students connect new lessons with prior learning experiences. One participant explained that new topics are deliberately linked to previously learned concepts to strengthen understanding and retention. Another participant emphasized that repeated encounters with concepts allow learners to appreciate the interconnectedness of scientific ideas and develop a more integrated understanding of science. These findings suggest that teachers perceive conceptual reinforcement not as repetitive instruction but as a strategic process of cognitive scaffolding designed to support progressive learning.

Document analysis further reinforced these narratives. Lesson plans and instructional materials frequently contained sections labeled "Review of Past Learning", "Connecting to Previous Concepts", and "Bridging Activities." Grade-level lesson plans revealed intentional references to concepts taught in earlier years, demonstrating how teachers institutionalize conceptual continuity within classroom practice. For example, ecology lessons revisited prior discussions on food chains and energy flow before introducing more complex ecological interactions. Such instructional designs illustrate the practical enactment of spiral progression in science education.

Another important aspect of this theme involved linking prior knowledge to new lessons. Teachers described how activating students' existing knowledge serves as a foundation for introducing more advanced concepts. Participants reported using questioning techniques, recall activities, visual organizers, and concept maps to assess students' readiness and establish conceptual bridges. These strategies enabled learners to situate new information within existing cognitive frameworks, thereby facilitating deeper understanding.

The findings support previous studies suggesting that conceptual continuity contributes significantly to learner retention and knowledge transfer. Harden and Stamper (2015) argued that spiral curricula promote long-term understanding because learners repeatedly encounter concepts at increasing levels of sophistication [2]. Similarly, Bruner (1960) emphasized that recurring engagement with concepts enables learners to refine and reconstruct understanding over time [1]. The experiences of the participants demonstrate how these theoretical principles are operationalized within actual science classrooms.

The findings also highlight the role of teachers as mediators of conceptual progression. Teachers constantly monitor learners' readiness, identify misconceptions, and adjust instructional pacing to ensure meaningful progression. Their experiences reveal that successful implementation of SPA depends not only on curriculum design but also on teachers' pedagogical expertise in facilitating cognitive connections across grade levels.

## 9.2. Promoting inquiry, engagement, and learner-centered practices

A second major theme centered on the use of inquiry-oriented, engaging, and learner-centered instructional approaches. Participants consistently described science learning as most effective when students actively participate in constructing knowledge through exploration, investigation, experimentation, and collaboration. Teachers viewed inquiry-based learning as an essential component of SPA because it allows learners to revisit concepts through authentic scientific experiences rather than passive content acquisition.

Participants reported frequent use of hands-on activities, laboratory investigations, simulations, problem-solving tasks, collaborative projects, and guided inquiry exercises. These instructional approaches enabled students to explore scientific phenomena, formulate explanations, and apply concepts to real-world situations. Teachers noted that inquiry-based activities increase student curiosity and engagement while strengthening conceptual understanding. Many participants described experimentation as a powerful mechanism for transforming abstract scientific ideas into concrete and meaningful experiences.

The emphasis on inquiry-based learning aligns with contemporary perspectives on science education. Aldossari (2018) argued that inquiry-oriented instruction promotes active engagement, critical thinking, and conceptual understanding by positioning learners as investigators rather than passive recipients of information [3]. Likewise, Darling-Hammond et al. (2017) found that active learning experiences contribute significantly to deeper understanding and long-term retention of scientific concepts [4].

Participants also emphasized the importance of student-centered learning and differentiation. Teachers described modifying instructional approaches to accommodate diverse learner needs, interests, readiness levels, and learning styles. Strategies such as flexible grouping, differentiated tasks, remediation sessions, enrichment activities, and scaffolded instruction were commonly employed to ensure that all learners could participate meaningfully in science learning.

Several participants explained that students enter classrooms with varying levels of prior knowledge and readiness. Consequently, teachers must adapt instruction to address learning gaps while maintaining curriculum progression. Participants described providing additional support to struggling learners through simplified explanations, guided practice, visual aids, and supplementary learning materials. At the same time, more advanced learners were challenged through enrichment activities and higher-order thinking tasks.

The findings support Tomlinson's (2017) assertion that differentiated instruction is necessary for addressing learner diversity and maximizing educational outcomes [5]. Within the context of SPA, differentiation becomes particularly important because conceptual progression assumes continuity of prior learning. Teachers therefore serve as facilitators who ensure that learners can successfully engage with increasingly complex scientific concepts regardless of their starting point.

Sustaining student engagement and motivation emerged as another significant aspect of this theme. Participants reported using contextualized examples, interactive activities, collaborative learning experiences, and real-life applications to maintain students' interest in science. Teachers emphasized that meaningful learning occurs when students perceive science as relevant to their everyday experiences. By connecting scientific concepts to community issues, environmental concerns, and familiar situations, teachers increase learner engagement and motivation.

This finding supports the work of UNESCO (2022), which emphasized the importance of contextualized and culturally responsive instruction in promoting meaningful learning [6]. When science concepts are situated within learners' lived experiences, students are more likely to develop positive attitudes toward science and sustain interest in scientific inquiry.

Another subtheme involved promoting critical thinking and analytical skills. Teachers described instructional activities that encourage students to interpret data, analyze evidence, identify patterns, formulate explanations, and justify conclusions. Rather than focusing solely on content recall, participants emphasized the importance of developing scientific reasoning and problem-solving abilities. Through inquiry activities, investigations, and reflective discussions, learners are challenged to engage in higher-order thinking processes that support scientific literacy.

Technology integration also emerged as a valuable pedagogical practice. Participants reported using multimedia resources, virtual simulations, online platforms, educational videos, and interactive presentations to enhance science instruction. Technology was particularly useful when laboratory resources were unavailable or insufficient. Teachers explained that simulations enable students to visualize abstract concepts and engage with scientific processes that may be difficult to replicate physically.

The integration of technology aligns with findings by Quintos et al. (2022), who reported that digital tools enhance engagement, accessibility, and conceptual understanding in science education [14]. Participants viewed technology not as a replacement for hands-on learning but as a complementary resource that expands instructional possibilities and supports continuity of learning.

Collectively, these findings demonstrate that science teachers employ a wide range of learner-centered and inquiry-oriented pedagogical practices to facilitate conceptual progression under SPA. Their instructional approaches reflect a commitment to active learning, differentiation, engagement, and critical thinking, all of which contribute to meaningful science learning.

## 9.3. Navigating instructional challenges and adaptive teaching practices

The third major theme captured the challenges encountered by science teachers and the adaptive practices they employ to sustain instruction. While participants acknowledged the pedagogical strengths of SPA, they also described numerous structural and contextual constraints affecting implementation. These challenges included resource limitations, curriculum congestion, specialization mismatch, time constraints, and learner diversity. Despite these difficulties, teachers consistently demonstrated resilience, creativity, and professional commitment.

Resource constraints emerged as one of the most persistent challenges. Participants reported inadequate laboratory equipment, insufficient instructional materials, outdated science resources, and limited access to technological tools. Teachers explained that the inquiry-based nature of science education requires resources that support experimentation and investigation. However, many schools lack the facilities necessary for optimal implementation of laboratory-based instruction.

To address these limitations, teachers developed various adaptive strategies. Participants described improvising laboratory activities using locally available materials, utilizing virtual simulations, modifying experiments, and collaborating with colleagues to share resources. Focus group participants reported substituting traditional laboratory activities with demonstrations and household materials when equipment was unavailable. These adaptive practices illustrate teachers' ability to maintain instructional quality despite resource limitations.

Curriculum congestion and time limitations constituted another significant challenge. Participants explained that the extensive number of competencies prescribed under SPA often creates pressure to complete content coverage within limited instructional time. Teachers reported difficulty balancing curriculum pacing with opportunities for inquiry, discussion, and conceptual exploration. Some participants noted that they are occasionally forced to prioritize coverage over depth, potentially affecting the quality of learning experiences.

These findings are consistent with Oducado (2021), who observed that curriculum congestion remains a major concern among science teachers implementing SPA [7]. The pressure to address numerous competencies can limit opportunities for meaningful inquiry and conceptual development. Participants in the present study similarly expressed concerns regarding pacing demands and instructional time constraints.

Specialization mismatch also emerged as a recurring issue. Many participants reported teaching science disciplines beyond their areas of academic preparation. Because SPA requires integration of Biology, Chemistry, Physics, and Earth Science across grade levels, teachers frequently encounter content areas in which they have limited formal training. Participants described spending considerable time preparing lessons, studying unfamiliar content, and seeking additional learning resources.

This finding supports previous research indicating that teaching outside one's specialization can affect instructional confidence and preparation demands. Teachers emphasized the need for sustained professional development opportunities focusing on content mastery, interdisciplinary instruction, and curriculum integration.

Learner diversity represented another challenge influencing implementation. Participants described wide variations in students' prior knowledge, learning pace, academic readiness, and motivation. Teachers explained that some learners struggle to retain prerequisite concepts, making it difficult to build progressively toward more advanced competencies. In response, participants employed differentiated instruction, remediation programs, supplementary materials, and individualized support.

Document analysis revealed frequent annotations such as "Need reinforcement activity", "Use visual simulation", and "Conduct remedial session", indicating ongoing efforts to address learner needs. Teachers often extended learning opportunities beyond regular class hours and provided additional resources to support struggling students.

Despite these challenges, participants consistently demonstrated adaptability and resilience. Teachers viewed challenges not merely as barriers but as opportunities for innovation and professional growth. Their experiences highlight the importance of reflective practice, continuous learning, and instructional flexibility in sustaining science education under SPA.

The findings underscore that curriculum implementation is not a linear process but a dynamic interaction between policy expectations and classroom realities. Teachers continuously negotiate curricular demands, resource constraints, learner needs, and institutional conditions while striving to maintain meaningful science learning experiences. Their experiences illustrate the critical role of teacher agency in translating curriculum reforms into effective classroom practice.

Overall, the results reveal that the implementation of SPA is characterized by deliberate efforts to deepen conceptual understanding, promote inquiry-based and learner-centered instruction, and navigate complex instructional challenges through adaptive practices. These findings informed the development of the proposed Spiral Progression Enhancement Framework, which emphasizes recursive conceptual learning, inquiry-based instruction, contextual integration, instructional adaptation, reflective assessment, and institutional support as essential components of effective science curriculum implementation.

## 10. Proposed framework: Spiral Progression Enhancement Framework (SPEF)

Based on the findings of the study, the Spiral Progression Enhancement Framework (SPEF) was developed to illustrate the interconnected processes that support effective implementation of the Spiral Progression

Approach (SPA) in Junior High School Science. The framework emerged from the lived experiences, pedagogical practices, and adaptive strategies of science teachers who continuously facilitate learning progression despite contextual and instructional challenges.

The framework recognizes that successful implementation of SPA extends beyond curriculum design and requires the dynamic interaction of pedagogical, cognitive, learner-centered, and institutional factors. It positions teachers as active facilitators of conceptual progression who intentionally connect prior knowledge with new learning experiences while responding to diverse learner needs and contextual realities.

## 11. Conclusion

The experiences of Junior High School science teachers reveal that effective implementation of the Spiral Progression Approach requires continuous conceptual reinforcement, inquiry-based instruction, learner-centered adaptation, and reflective teaching practice. While teachers demonstrate adaptability and commitment in implementing SPA, persistent challenges related to curriculum demands, teacher specialization, and resource limitations continue to affect instructional delivery. The proposed Spiral Progression Enhancement Framework highlights the interconnected roles of recursive conceptual learning, instructional adaptation, contextual integration, reflective assessment, and institutional support in promoting meaningful and continuous science learning. Strengthening these dimensions may contribute to more effective implementation of the Spiral Progression Approach and improved science education outcomes.


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## Disclosure statement

The authors declare no conflict of interest.

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