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Teaching Practices of Elementary Science Teachers in Bontoc District: Bases for a Training Program

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Abstract

Aim: This study aimed to explore the teaching practices of elementary teachers handling Science classes in the Bontoc District, where limited data exist, and to determine how these practices influence student learning outcomes. The results of this exploration served as the basis for a proposed training program.

Methodology: The study employed a qualitative exploratory research design to examine the teaching practices and challenges encountered by elementary Science teachers in Central Bontoc. Data were gathered through interviews, Focus Group Discussions, and triangulations and analyzed thematically.

Results: The study found that science teaching practices among elementary teachers encompass facilitative, evaluative, and integrative approaches that foster an engaging learning environment. However, several challenges hinder effective science instruction, including limited instructional time, insufficient resources, difficulty in teaching abstract concepts, and a lack of experiential or outdoor science activities.

Conclusion: The study identified the prevailing teaching practices of elementary Science teachers in Central Bontoc and revealed several limiting factors that hinder effective teaching instruction. The findings underscore the need for targeted professional development programs focused on effective science instruction. In line with these findings, a training program was developed to specifically address the identified challenges. The proposed program aims to enhance Science teaching effectiveness, promote conceptually rich learning experiences, and foster sustained improvement in Science education within the Bontoc District.

Keywords: *exploratory research, science teaching practices, elementary teachers, instructional challenges, teacher training program*

INTRODUCTION

The need for more effective science teaching in the Philippines has long been a national priority, as advances in science signify both modern life and national progress. However, a global learning crisis persists, especially in developing countries, where access to schooling has expanded but learning outcomes remain poor (The World Bank et al., 2022). This is evident in international assessments that revealed a persistent global learning gap extending to national and regional levels. In the Philippines, particularly the Cordillera Administrative Region (CAR), similar patters emerge, highlighting systemic instructional challenges that demand localized examination.

The Trends in International Mathematics and Science Study & Progress in International Reading Literacy Study International Study Center (TIMSS & PIRLS International Study Center, 2019) recorded the Philippines' Science score at 249, the lowest score among participating countries. Similarly, in the Program for International Student Assessment (PISA), the country scored 357 in Science (The World Bank et al., 2022), placing it among the lowest in the Organisation for Economic Co-operation and Development (OECD).

These global and national challenges are likewise reflected in regional and local assessments as shown in the results of the Regional Assessment Test 2022 (Department of Education-Cordillera Administrative Region [DepED-CAR], 2022) and the Division Initiated Periodical Assessment 2021-2022 by the Department of Education-Division of Mountain Province (DepED-Division of Mountain Province, 2022). Reports revealed that Science proficiency of learners is below the standard of 75%, with elementary Science recording the highest proportion of

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learners in the "Did Not Meet Expectations" category. The Bontoc District belongs to DepED-Division of Mountain Province where these DNME results are reported.

Teacher performance mirrors these results. As unveiled in the Basic Education Development Plan 2030 (DepED, 2022), many elementary teachers lack skills in analysis, synthesis, and evaluation with some failing to demonstrate adequate subject knowledge. On this note, the World Bank (Chi, 2023) emphasized that poor learning outcomes are linked to ineffective teaching practices, noting that only 7% of teachers in the Philippines employ highly effective teaching practices. Multiple studies confirm that teacher quality and teaching practices significantly influence student achievement (Tomaszewski et al., 2022; OECD, 2021).

Teaching practices, defined as the application of instructional, pedagogical, and technical strategies are influenced by beliefs, prior experiences, content mastery, and pedagogical skills (DeJaeghere et al., 2021). Cognitive development theories by Piaget (1964) and Vygotsky (Van der Veer, 2020) discusses that appropriate teaching practices at each developmental stage promote positive learning outcomes. Despite this, Philippine classrooms remain largely teacher-centered (Atta et al., 2021; Jackaria, 2022) contrary to evidence showing that learner-centered approaches improve Science performance (Palines & Ortega-Dela Cruz, 2021; Picardal & Sanchez, 2022).

Internationally, the Education 4.0 advocates for the integration of information and communications technology (ICT) to enhance instructional delivery (Atasoy, 2023) and has been linked to innovative teaching practices (González-Pérez & Ramírez-Montoya, 2022; Srivani et al., 2022). However, many Filipino Science teachers remain unfamiliar with the Education 4.0 principles (Tupas & Noderama, 2020), evident in a 2022 (Tijap et al., 2022) study revealing the need on continuous training in effective use of various online learning platforms, and further enhancement of competencies in implementing technology-integrated teaching strategies to meet the demands of the Education 4.0.

Other barriers to effective Science teaching include insufficient content mastery (Degorio, 2022; Lucero, 2021), lack of instructional time (Nikki, 2024) and resources (Sosyal & Radmard, 2022), inadequate professional development (Chi, 2023), and heavy workloads (Tarraya, 2023). Although training programs can improve teacher proficiency, many do not address teachers' actual classroom needs.

While numerous studies link effective teaching practices to improved Science achievement, several gaps persist. First, there is no documented study focusing specifically on the teaching practices of elementary teachers who are teaching Science in Mountain Province. Existing findings are drawn from national or other regional contexts that may not accurately represent the rural, highland educational settings. Second, although Education 4.0 has been widely adopted globally, its integration into Philippine elementary Science teaching is minimal, with many teachers lacking awareness of its principle. Third, despite strong international evidence supporting learner-centered practices, these methods are underutilized in the Philippines, particularly in rural settings, where teacher-centered practices remain prevalent (Atta et al., 2021; Jackaria, 2022). Lastly, professional development programs are often misaligned with teachers' pedagogical and content needs (Chi, 2023).

The study is anchored on the Cognitive Theory of Development by Piaget and Vygotsky, which emphasize that learners' cognitive growth unfolds through developmental stages and is shaped by interaction, experience, and instruction. In elementary education, these theories suggest the need for developmentally appropriate teaching practices to match learners' cognitive capacities that strengthen learner's cognitive foundations for higher-level learning.

The Bontoc District, part of the Schools Division of Mountain Province, comprises 19 elementary schools categorized into big, small, multigrade, and primary schools. Exploring the teaching practices in this district is crucial, as elementary education serves as the formative stage for developing learners' cognitive skills that would influence long-term academic outcomes. Examining how teachers facilitate learning at this level helps to the broader discourse on Science education by contextualizing global teaching standards within a rural Philippine setting. It introduces a localized framework for enhancing Science pedagogy through Education 4.0 principles, thereby providing a model for evidence-based teacher training responsive to the distinct needs of elementary schools in the Bontoc District, addressing persistent low performance in international (PISA and TIMSS & PIRLS) and local evaluations (CAR Regional Assessment Tests, Division Periodical Assessments).

Hence, this study sought to explore the teaching practices of elementary Science teachers in the Bontoc District to identify their strengths and constraints. The findings are expected to inform the design of a contextualized professional development program that aligns with Education 4.0 principles and local classroom realities.

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Statement of the Problem

Science education plays a crucial role in equipping learners with the knowledge, skills, and attitudes necessary for technological advancement and sustainable national development. However, despite curriculum reforms and teacher training initiatives, science performance among Filipino learners remains consistently below international standards. Results from the TIMSS & PIRLS 2019 and the PISA 2022 indicated that the Philippines continues to rank among the lowest in Science proficiency. Regional and local assessments, including those administered by the DepEd–CAR and the Schools Division of Mountain Province, reveal similar trends of underachievement among elementary learners. These outcomes are often attributed to teaching practices that are heavily teacher-centered, lack of appropriate instructional resources, insufficient content mastery, and limited professional development opportunities.

In the context of Central Bontoc District, where schools are geographically dispersed and often resource-constrained, elementary Science teachers face additional challenges in implementing engaging and inquiry-based lessons. Despite the critical importance of early Science education, there is a lack of documented studies examining how elementary teachers in this District teach Science, what challenges they encounter, and what support they require to improve their instructional delivery. Addressing this research gap is vital to enhancing Science education quality in the region. Thus, this study investigates the teaching practices of elementary teachers in Science, identifies the limiting factors affecting their instructional performance, and proposes a contextualized training program to strengthen Science teaching in Central Bontoc.

Research Objectives

This study generally explored the teaching practices of elementary Science teachers in Central Bontoc District, Mountain Province, as a basis for developing a contextualized training program.

Specifically, it sought:

1. To identify the teaching practices of elementary teachers in teaching Science in Central Bontoc;
2. To determine the limiting factors affecting the teaching practices of elementary teachers in teaching Science in Central Bontoc; and
3. To develop a training program designed to address the limiting factors identified in the Science teaching practices of elementary teachers in Central Bontoc.

Research Questions

To address the objectives of the study, the following research questions were formulated:

1. What are the existing teaching practices of elementary Science teachers in Central Bontoc District?
2. What limiting factors influence the teaching practices of elementary Science teachers in Central Bontoc District?
3. What training program can be developed to address the limiting factors affecting the Science teaching practices of elementary teachers in Central Bontoc District?

METHODS

Research Design

This study utilized a qualitative approach, specifically an exploratory research design. Exploratory research allows for a better understanding of topics or areas that have limited or no information. An exploratory research design fits this study as there are limited prior studies on the teaching practices of elementary Science teachers in Mountain Province, specifically in the Bontoc District, and its primary goal is to generate insights, identify emerging patterns, and build and initial understanding of the phenomenon under study (Hassan, 2024).

Population and Sampling

The study was conducted in Bontoc, Mountain Province, specifically in the elementary schools of Central Bontoc, Bontoc District during the school years 2022-2023 and 2023-2024. Since there is a limited number of elementary Science teachers in the locality, the study used purposive and criterion sampling in selecting the respondents. The respondents were ten elementary Science teachers in Central Bontoc who met all the criteria: one year and above of science teaching experience; belong to a private or public elementary school in Central Bontoc; belong to a small or big school; and are willing to participate in the study.

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Instruments

In identifying the teaching practices and limiting factors in the teaching science of elementary teachers, researcher-made open-ended guide questions for the interview and focus-group discussion were used. The content of the guide questions was validated by five science teachers with more than five years of experience in teaching science, ensuring that the questions contained necessary information in relation to the three objectives of this study in accordance with a process by Taherdoost (2022). After content validation, the guide questions were revised in compliance with the comments and suggestions of the validators.

Data Collection

Data were gathered through individual interviews and focus group discussions (FGDs). Individual interviews explored participants' experiences in- depth (Taherdoost, 2022), while FGDs complemented interviews by confirming, expanding, or providing alternative perspectives (Gill & Baillie, 2018). The first round of interviews took place in the fourth quarter of the DepEd's academic year 2022-2023, with each interview lasting twenty to thirty minutes in the participants' respective classrooms. The second round of interviews occurred in the first quarter of the DepEd's academic year 2023-2024 to validate and clarify responses from the initial sessions. For schools with multiple participants, focus group discussions were held to corroborate and elucidate the information gathered during the interviews. Additional triangulation was achieved through brief interviews with school principals, which provided contextual insights that supported the interpretation of teacher response.

Data Analysis

Interview and FGD transcripts underwent thematic analysis, specifically template analysis. In this method, an initial coding framework or template was developed and refined through iterative reading of the transcripts. This process allowed flexibility in redefining and relating themes while maintaining analytical rigor. To enhance the credibility of the findings, participants were given the opportunity to review and confirm the accuracy of the transcriptions and interpretations of emerging themes. Repeated reading of the verified transcripts enabled the identification of common keywords, phrases, and statements, which were organized into thematic categories.

Similarly, the analysis of factors limiting the teaching of elementary Science were done through thematic template analysis. These constraints served as the basis for designing a contextualized training program responsive to the emerging needs of teachers in the study area.

Ethical Considerations

The researcher adhered to the 2012 Data Privacy Act, in taking reasonable precautions to protect participants details. To ensure this, respondent's names and schools were at no point revealed in this study.

A permit to conduct the study was secured from the Office of the Public Schools Division Supervisor-Bontoc District and the principals of the participating schools. Consent forms were distributed to the respondents prior to interviews and focus group discussions. Participants were informed of the objectives of the study, assured of confidentiality and privacy, and reminded of their right to withdraw at any time. Participants were also notified that interviews and discussions would be audio-recorded for reference. All recordings were securely stored in a password-protected file to ensure confidentiality and integrity of the information gathered.

Although school principals were not identified as participants, their perspectives were sought solely for data triangulation and contextual validation with their informed consent. In cases where direct quotations were cited, these were used solely to clarify interpretations and were presented anonymously without identifying details. They were informed that their inputs would only serve as supplementary evidence to enhance credibility of findings.

RESULTS and DISCUSSION

This section presents the analysis and interpretation of the data gathered from the elementary teachers teaching Science in the Bontoc District.

1. **Teaching Practices**

Themes

Facilitative practices
Assessment and evaluation practices
Integrative practices

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1.1 Facilitative practices

The DepED Science curriculum separates Science as a learning area beginning in Grade 3. Teachers in Central Bontoc preferred facilitative discussions to traditional lectures. Lessons began with open exchanges between teachers and learners, followed by engaging group activities. This collaborative approach encouraged peer interaction and supported conceptual understanding. The following are sample transcripts from the interview:

"Teacher 1: '. . ang mga grade three, laro laro pa ang alam nila kaya kailangang pag group work o kahit anong activity kailangan nakagabay ka talaga or else magiging playground ang room. . . ' (. . grade 3 learners are playful, thus there really is a need for a close monitoring during group works or any activities or else the room would become a playground. .)"

Groupwork was enhanced through ICT-based strategies such as PowerPoint and Lumi applications, which made lessons more interactive and engaging (Deysolong, 2023). Additionally, digital platforms such as Facebook Messenger were also used to maintain communication with parents and learners. Bylieva and Nordmann (2023) highlights that these chats support motivation. It showed how both digital tools and parent communication enhance collaborative and interactive learning, particularly in Grades 5 and 6, by sending assignments and updates, while in grades 3 and 4, they serve as parent reminders.

"Teacher 3: '..waday group chat with parents not with pupils. Sya nan kagawisana ad wanin ya tay waday cellphone ya nalaklaka makicommunicate ka parents karkaru nu waday assignment si kwela, pati nu waday announcement. . ' (. .we have a group chat with parents not with the pupils. This was considered one of the advantages of having cellphones nowadays as it is easier to communicate with parents especially for reminding their child's assignments, and with some announcements.)"

Practical work is another strategy teachers employ, often planned with learners and supported by community resources when school materials are lacking, reflecting learner-designed experiments (Sosyal & Radmard, 2022). However, limited instructional time often constrained the conduct of experiments, leading teachers to resort to demonstrations—a practice also noted by Sosyal and Radmard (2022).

"Teacher 5: '..nu waday laydek ipaila kendaida thru an experiment, mas laydek et ngay ay indemo na lang kaysa nan daida manggaeb is ka am amin tay baka kumurang nan time. . ' (if there is a thing that I would like them to see through an experiment, I would rather show it to them through a demonstration than for them to do it on their own for us to maximize the time.)"

Moreover, teachers emphasize giving both oral and written instructions to ensure clarity, as instructions can make or break an activity (Tait, 2011).

"Teacher 9: '..wen man adi umanay nan ibagbgam lang nan instruction, masapul ay isurat metlang, isurat ka activity paper da wenu ka board.. ' (..it is not enough that you provide oral instructions only, there is a need for written instructions, either written on a paper or on the board..)"

Lastly, storytelling further enhances science teaching, particularly in Grades 3 and 4, by personifying concepts for better engagement (Matamit et. al, 2020). When carefully prepared with instructional materials using digital technology (Rahiem, 2021), storytelling becomes a powerful tool. A sample transcript is shown below:

"Teacher 8: '..effective man jay storytelling nu elementary. Knyak, karkaru ngay nu systems of the body jay lesson ya haan da unay kay nga maawatan jay trabahon ti parts na isunga agaramd ta ti storyana. . '(.storytelling is effective in elementary. For me, especially if the lesson is on the systems of the body, they do not understand the science terms, therefore you make a story out of it for them to be able to relate to the functions of its parts.)"

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Overall, elementary teachers teaching Science in Central Bontoc blend facilitative discussions, collaborative work, practical activities, technology integration, clear instructions, and storytelling to engage learners and enhance learning. These findings affirm that effective facilitative practices in rural settings require a balance between contextual adaptation and adherence to national standards, reflecting the constructivist principles of Vygotsky's social learning theory.

1.2 Assessment and evaluation practices

For assessment and evaluation practices, Central Bontoc teachers measure learner's cognitive abilities and skill development through pen-and-paper tests and reporting. Learners orally present group outputs, summarize lessons, or share research assignments with Grades 4-6, often assigning reporters after group activities. This practice supports communication skills, a vital 21st -century competence essential for workplaces and social growth (Angganing, et al., 2023) as reflected in the transcripts:

"Teacher 7: '. . . we use rubrics or criteria in assessing and evaluating their reports, it is reflected naman in our lesson plan. . . nu nan skwela nan inkali ka sangu, mas attentive nan classmates da. . . ' (. . . we use rubrics or criteria in assessing and evaluating their reports, it is reflected in our lesson plan. . . when it is our pupils who will be talking infront, their classmates become attentive. . .)"

"Teacher 5: '..nu malpas [groupwork], irequire ko daida ay mangireport ka output da ka sangu, sya nan mangilaam nu naawatan da..' (at the end of [groupwork], learners are required to report their output infront, that would serve as an assessment..)"

Another common practice is giving immediate feedback, answers, and activity scores as reflected in the sample transcript below. Feedback, according to the DepED Philippine Professional Standards for Teachers (PPST) Resource Package Module 20 (Department of Education-Teacher Education Council [DepED-TEC], 2020), should be timely so learners can act on it.

"Teacher 2: '... yes we have to give post discussions on misconceptions and wrong answers. . . when we do not't, our pupils would always be asking for the correct answer and their score so we really need to give them immediately... '

Further, to promote active involvement, Teacher 7 uses peer evaluation, asking learners to justify their ratings. Peer feedback is recommended in DepED PPST Module 20 (DepED-TEC, 2020) emphasizes its goal should be for learning and improvement.

Moreover, differentiated instruction also fosters inclusivity, as Teachers 3 and 10 use drawing, painting, and games to suit different learning styles. Teacher 10 pairs slower with faster learners, and Teacher 5 designs separate activities for slow, average, and advance learners. The Principal of Teacher 5 noted in a separate interview for triangulation that these adaptations require clear explanations as presented in the following sample transcripts:

"Principal : '..kanak kendaida ay nu iintegrate da nan differentiated instruction ka assessment part, masapul ay ilan da ay usto nu applicable ba ay in usar si differentiated instruction, adi da aped in gaeb si sets of quizzes tapnu waday lang maisurat ay nausaran si differentiated instruction.' (..I always tell them that when they integrate differentiated instruction in assessing, they have to make sure that it is applicable, they should not make different sets of quizzes just to make an input that differentiated instruction was integrated.)"

On this note, differentiated instruction must be well-planned to ensure learner familiarity, suggesting professional development for teachers to implement it effectively in Science (Scott et al. (2021). It addresses various learner needs, strengths, interests, gender, and experiences.

1.3 Integrative practices

Guided by the integrated curriculum, Bontoc elementary teachers incorporate other subjects, affective objectives, health lesson, and anti-bullying campaigns into science, often integrating English and Mother Tongue by correcting grammar, spelling, and pronunciation to support fluency and reading comprehension (Da Costa & Reyes, 2021). A sample transcript is shown below:

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"Teacher 8: '..nan kanayon man ay ikorek ko ya nan spelling kn pronounciation si skwela, pati nan grammar. Sya nan esang ay mang-usaran sinan reporting, tapnu maila nu kas anu da ay inkali ken kasanu da ay maipronounce nan words..saet nu waday ages barbaru ay word ay usaren mi iska lesson, masapul ay iexplain kendaida nan meaning na..' (..I always correct their spelling and pronunciation, including their grammar..that is why reporting is a good training for us also to see how they speak in terms of pronunciation and grammar. and I also provide the meaning of new words that they meet.)"

Meanwhile, Mother Tongue is used for contextualization (DepED, 2016; DepED-TEC, 2020), mostly in Grades 3-5 for clearer explanations, and in Grade 6 for translations as shown by a transcript below:

"Teacher 8: '..adim makaan nan Mother tongue ay angnen mangiexplain nu nen English ka ya iilam ay kag da adi maawatan..' (..you cannot remove Mother tongue is explaining especially if you have explained in English and it's evident that the pupils do not understand it..)"

The respondents also emphasize affective learning through affirmations and name-calling. Positive reinforcement improves engagement and achievement (Rowell, 2023; Smith et al., 2021), while personalizing interaction thru memorizing names, fosters respect and comfort (Berning, 2023), supported by neurological evidence (Carmody & Lewis, 2006). A sample from the transcripts is shown below:

"Teacher 4: '..nan powerpoint waday da nan animations kag sin good job, very good, correct. Maipaila datudi nu correct nan answer da..' (..the powerpoint presentation is also integrated with animations that say good job, very good, correct, if they answer questions correctly.)"

In addition, health topics are integrated into affective objectives in lesson plans, relating discussions to health impacts (The World Bank et al., 2022) as reflected in the sample transcript:

"Teacher 5: '..in lesson planning kailangang may affective domain, most of the time the one being addressed is on health issues kasi dun mas nakakarelate ang mga bata.' (in lesson planning there is a need to include affective objectives, most of the time the one being addressed is on health issues for it is relatable to pupils..)"

Furthermore, antibullying is also integrated into science teaching as presented by the sample transcript below, promoting a safe and friendly school environment:

"Teacher 5: ..group activities are mostly used also to form friendship among students.. our schools should be providing a safe and friendly environment."

Overall, teachers in Bontoc integrate language, values, health, and safety into Science instruction, aligning with research and policy to foster both cognitive and socio-emotional development, consistent with the cognitive developmental theories of Piaget and Vygotsky.

2. **Limiting factors**

Themes
Time management
Lack of resources
Difficulty in teaching abstract concepts
Lack of extra-curricular activities

The study identifies key limiting factors in teaching elementary Science, drawn from teacher interviews and FGDs: time management, lack of resources, difficulty in teaching abstract concepts, and lack of outside-the-classroom activities. These themes emerged from recurring keywords, phrases, and statements from respondents.

2.1 Time management

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The foremost challenge in Science teaching in Central Bontoc elementary schools is the insufficient time to discuss findings from practical works, in-depth discussions, and feedback. Practical activities, though effective for abstract concepts, are least used due to preparation demands. Respondents emphasized Science requires more time for effective delivery and hands-on engagement. Below is a sample transcript:

"Teacher 6: 'Mamamingsan nan practical works tay nan preparation na..nan tupay kannay instruction ket in ala si oras.' (Practical works are sometimes are done being done because of its preparation time in giving instructions, time is already consumed.)"

Other studies echo this dilemma. The DepED Curriculum allots only 50 minutes daily for elementary Science as issued by DepED Order No. 31, S. 2012 (DepED, 2012). Sosyal and Radmard (2022) stressed that more time improves performance, suggesting curriculum makers to increase Science hours for practical work and early learner exposure.

2.2 Lack of resources

The second limitation is the shortage laboratory resources, prompting teachers to use demonstrations, videos, or household items. Additionally, no virtual laboratories were used by respondents, though promising (Manyilizu, 2023), due to lack of software and training. Below is sample transcript:

"Teacher 9: '. . .tay ampay kurang nan materials pang group work, demonstration et nan angnek and the kids will observe.. . ken nan esang, nu waday procedure ay medyo delikado for the kids, masapul ay demonstration.' (. . .since materials are not even enough for group activities, I demonstrate the procedure and the kids will observe. . .and another one, when there are procedures which needs extra care, I will do the demonstration. .)"

2.3 Difficulty in teaching abstract concepts

The third limitation is difficulty in teaching abstract Biological and Physical concepts in Grades 4-6. Teachers in Bontoc struggle with technical terms, topics like force, motion and energy, unseen biological systems, and sensitive areas such as reproduction: A sample transcript is shown below:

"Teacher 3: '.nan challenge nu teaching of science ya nu ka anu iexplain to little children nan lessons into real-life situations. Example, ka lesson mi ay reproductive system, tay grade 4 da et ya medyo inbabain da ya dak anapen nu kas anu maging mas open da sin nalay ay topic.' (..the challenge on teaching science is on how to explain to little children the lessons relating it to real-life situations. For example, in our lesson on reproductive system, grade 5 learners are starting to become aware of their body, therefore I need to find ways on how to make them more open about the topic..)"

These difficulties stem from limited specialized trainings (Tijap et al., 2022) highlighting the need for a professional development in pedagogical content knowledge to help learners grasp Science concepts, purposes, and real-life relevance.

2.4 Lack of extra-curricular activities

The last limitation identified is the limited outside-the-classroom science activities, where not all pupils can join, restricting exposure, especially for marginalized learners. Existing activities often focus only on tree planting or cleanup drives. This highlights the recommendation of University of the Philippines College of Mass Communications Foundation, Inc. & Department of Science and Technology—Science Education Institute (UPMCFI and DOST-SEI, 2021) of doing hands-on experiments, field trips, and scientist interactions to enhance Science, Technology, Engineering, and Mathematics (STEM) learning. Similarly, Grinnell (2020) emphasized that science fairs should be redesigned to include non-competitive science fairs or science programs to allow exploration of new scientific ideas in diverse settings.

The emerging themes from the interviews and focus group discussions guided the formulation of a contextualized professional development program designed to address the identified challenges in Science instruction.

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3. Training program to address limiting factors

In light of the gathered data, the researcher developed a professional development training program that may be adopted by the DepED or by other institutions for elementary teachers who are teaching in Science. Such a program helps address factors affecting science education quality supported by Republic Act (RA) 232 and the Philippine Professional Standards for Teachers (PPST). In RA 232, The Education Act of 1982: Chapter 3, Duties and Obligations, Section 16 (4), teachers are mandated to maintain professional growth and advancement. This commitment aligns with PPST, which emphasizes continuous professional learning and engagement throughout a teacher's career.

The program seeks to address four limitations in elementary science teaching: time management, lack of resources, difficulty in teaching abstract concepts, and limited outside-the-classroom activities. Structured across a school year, it consists four components: (1) Training on Teaching Strategies, aimed at broadening approaches for engaging Science lessons and maximizing instructional time; (2) Training on Teaching Abstract Science Concepts, equipping teachers with methods for delivering complex topics; (3) Training on Virtual Laboratories, introducing digital simulations as substitutes for limited laboratory access; and (4) Training on Organizing Outside-the-Classroom Science Activities, empowering teachers to plan science camps. Together, these components aim to enhance teacher's knowledge, skills, and resources to provide effective and engaging learning competencies.

The first two components, aligns with the OECD's (2021) emphasis for teachers to update their skills, changing educational settings, including adapting to curricula, research findings, and evolving learners' needs. The World Bank et al (2022) likewise highlights continuous in-service training to optimize instructional time. Studies show that updating teaching strategies positively impacts classroom practices (Lucero, 2021; Paz, 2021; Tijap et al., 2022). Participants in these trainings will design lesson plans that integrate effective teaching strategies for elementary Science while maximizing time allotment and discussing abstract concepts.

The third component addresses the lack of laboratory resources by familiarizing teachers with virtual laboratories, aligned with the Education 4.0. Research has shown that virtual laboratories enhance learners' attitudes and skills by simulating traditional experiments, encouraging a learner-centered learning process (Zhang et al., 2024). Elementary learners, being playful and curious, respond well to virtual labs that engage them in active exploration (Santos & Prudente, 2022; Manyilizu, 2023; Shadbad et al., 2023). Teachers will be trained to navigate and integrate these tools into lesson planning and classroom teaching.

Finally, the fourth component promotes outside-the-classroom learning by training teachers to design science camps. Such activities engage learners through experiments, discoveries, and innovations, nurturing scientific skills. Internationally, science camps are valued for exposing young learners to STEM and encouraging future participation, while promoting gender equality and innovation (Reed et al., 2022). These activities may be integrated into culminating school events, aligning with the DepED PPST Resource Package Module 1 (DepED—Teacher Education Council, 2020).

If adopted, the effectiveness will be monitored using the DepED's Result-based Performance Management System (RPMS) (DepED, 2015). School leaders and master teachers will evaluate implementation using the Classroom Observation Tool (COT), which measures content, strategies, and ICT integration. Outside-the-classroom Science activities will be evaluated using the STEM evaluation tool by Okulu & Oguz-Unver (2021) completed by learners after participation.

Conclusions

The research results offer the following conclusions that may guide science educators, curriculum planners, and policymakers in enhancing elementary science teaching in Bontoc District:

1. Elementary teachers employed facilitative, evaluative, and integrative practices that addressed learners' cognitive and non-cognitive skills.
2. The teachers encountered limitations in explaining abstract concepts, managing time, and accessing laboratory resources, with limited
3. opportunities for outside-the-classroom science activities.
4. A specialized science training program was developed designed to address the limiting factors in Science teaching practices.

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Recommendations

1. Elementary teachers may consider planning lessons in advance and utilizing virtual laboratories to maximize instructional time and hands-on learning.
2. Elementary teachers teaching Science, particularly non-Science majors, may engage in continuous professional development through advanced studies and specialized Science seminars to address identified constraints.
3. The DepED–Bontoc District may explore adopting and funding the proposed training program to promote equitable professional development.

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