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Predicting Elementary Learners' Performance Through a Regression Model Based on Teachers' Knowledge, Practices, Attributes, and Teaching Skills

Milagros C. Sta. Rita
Tangil Elementary School, Dumanjug II District, Schools Division of Cebu Province, Department of Education, Dumanjug, Cebu, Philippines

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Email of Corresponding Author: milagros.starita001@deped.gov.ph

Abstract

This study determined the effectiveness of science teachers and examined its influence on the academic performance of elementary learners in selected schools in Dumanjug Districts I and II, Cebu Province. It aimed to develop a regression model based on teachers' professional knowledge, professional practices, professional attributes, and teaching skills as predictors of learners' academic performance in science. The study was anchored on Behaviorism and Social Constructivism, with United Nations (n.d.) and Department of Education (2017) on the Philippine Professional Standards for Teachers serving as legal and educational bases. A quantitative research design was employed using adapted survey questionnaires to gather data from 130 science teachers and 1,300 learners. Teachers' effectiveness was assessed in terms of professional knowledge, professional practices, professional attributes, and teaching skills, while learners' academic performance was measured using Grade Point Average and class Mean Percentage Score. The data were analyzed using simple percentage, weighted mean, Pearson-r correlation, and regression analysis. The findings revealed that teacher-respondents and learner-respondents generally classified science teachers as Master Science Teacher in professional knowledge, professional practices, and professional attributes. Teaching skills were also rated highly, with several indicators classified as Certified Science Mentor. Learners' academic performance in science was mostly Very Satisfactory based on both Grade Point Average and class Mean Percentage Score. Correlation results showed that professional practices had the strongest positive relationship with learners' academic performance, followed by teaching skills, professional knowledge, and professional attributes. The regression model indicated that teacher-related factors meaningfully predicted learners' academic performance, with professional practices showing the strongest influence. The study concluded that science teachers' ability to handle subject content, manage classroom learning, facilitate instruction, and apply effective teaching practices contributes to learners' academic success in science. It recommended the adoption of a regression-based model and a faculty development plan to strengthen teachers' knowledge, practices, attributes, and teaching skills. The study supports SDG 4 – Quality Education because it focuses on improving teacher effectiveness and learner performance in basic science education. Its sustainability impact is primarily educational and institutional, as it provides evidence for professional development, instructional improvement, and data-based planning that may support long-term enhancement of science teaching and learning.

Keywords: Academic Performance, Development Education, Dumanjug Cebu, Professional Attributes, Professional Knowledge, Professional Practices, Regression Model, Science Teachers, Teaching Skills, Teachers' Effectiveness

1. Introduction

Education aims to develop learners holistically through 21st century skills, values education, and competencies needed for life, career, personal growth, and professional success. These goals can be achieved when teachers are also equipped with the necessary professional capabilities (Zamora et al., 2022). Teaching quality plays a vital role in learners' academic achievement because learning tasks, facilitation, and instructional delivery contribute to academic success, as emphasized by Sophuan (2018). Smith (2016) further stated that capable teachers significantly influence learners' lives, while the experiences of high-performing countries such as Canada, Poland, Finland, Korea, and Singapore show that teacher quality contributes to high-quality learner outcomes (Partelow et al., 2017). The Philippines, however, continues to face educational challenges. In the 2018 Program for International Student Assessment, the Philippines ranked second from the bottom among 79 participating countries in mathematics, reading, and science, with mean scores below the survey average (Ambag, 2018). This national concern is reflected in Dumanjug II public elementary schools, where learners obtained the lowest Mean Percentage Score in the National Assessment Test in Science and Mathematics. Although equipment, instruction, and facilities are considered relevant factors, Sumyadi et al. (2020) emphasized that the quality of teachers' discussion affects learners' achievement. To respond to these concerns, teachers must demonstrate Professional Knowledge, Professional Practice, and Professional Attributes (UP NISMED-JICA-DepED, 2007), together with teaching

skills such as clarity, sustainability of content, activities, interaction, media use, questioning, and individual style. These dimensions form the basis for assessing teacher effectiveness and predicting learners' academic performance.

The literature indicates that professional competence is a major factor in improving learners' abilities. Teachers must possess deep subject understanding and practical classroom experience to create attractive and effective learning environments, as discussed by Prasetio et al. (2017). Nbina (2012) found a significant relationship between teachers' competence and students' academic performance in chemistry, while Allen & Fraser (2007) reported a strong connection between teacher competence, classroom atmosphere, and student outcomes. Ferdinand and Andala (2023) also concluded that teachers' subject expertise, teaching method, student participation, and good instruction promote learners' academic performance. Pedagogical competence is also essential. Akpan (2002) described pedagogical competence as the art of teaching, involving the movement from known to unknown, concrete to abstract, and simple to complex concepts. Podungge et al. (2020) showed that teacher competence directly influences academic achievement by increasing learners' intrinsic motivation. Mareike et al. (2013) found that pedagogical content knowledge, professional beliefs, work-related motivation, and self-regulation positively affect learning outcomes. Akinbobola (2004) added that competent teachers attend professional development activities, manage classrooms properly, communicate effectively, use varied methods, and show enthusiasm.

Several studies also connect teacher competence with learning environment and technology. Prihantoro et al. (2019) found significant links among teacher competence, learning environment, and learner achievement, although Sultan and Shafi (2014) found that classroom environment had no effect or relationship with teacher competence and student performance. Linsiyah et al. (2023) showed that professional competence combined with learning styles influences learners' achievement, while Ali et al. (2020) and Ali et al. (2022) highlighted the positive effect of professional knowledge, pedagogical skills, and technology integration on learners' achievement. Teaching skills also influence academic learning. Gultom et al. (2020) identified questioning, reinforcement, variation, explanation, opening and closing, small group discussion, classroom management, and individual style as important teaching skills for increasing learners' interest. Cooper & Ozansoy (2022) found that teaching strategies affect student performance, although Norwani et al. (2017) reported no significant relationship between teaching skills and student achievement. Adediwura & Tayo (2007) found that teachers' knowledge, attitude, and teaching skills predict learners' academic performance. Khan et al. (2017) further emphasized the role of communication skills in promoting critical thinking and academic success.

Classroom practices are likewise linked to academic performance. Wenglinsky (2002) found that classroom practices contribute to academic learning, while Kimani et al. (2013) reported a significant and positive relationship between teachers' classroom practices and learners' academic achievement. Nazari & Far (2019), however, found that teaching skills were not significant to academic achievement, although they influenced academic stress and learners' mindset. Professional knowledge supports teacher effectiveness. Teachers are key figures in promoting literacy, professional knowledge, and competence (Jurik et al., 2014). Yuan et al. (2017) found significant relationships among professional development, competence, knowledge, teacher efficacy, and professional competence. Liakopoulou (2011) verified that pedagogical knowledge and personal traits contribute to teacher effectiveness. Canrinus et al. (2012) explained that teachers must participate in learning tasks to enhance professional knowledge, skills, and attitudes, while Gul et al. (2020) showed that professional knowledge helps teachers identify classroom challenges and learning gaps. Tleuzhanova and Madenyatova (2014) also identified professional skills and knowledge as qualities that contribute to teacher effectiveness.

Professional practice also shapes teacher effectiveness. Bachtiar (2020) found that professional development activities that increase knowledge and skills, encourage collaboration, and address classroom needs improve teacher effectiveness. Andrin et al. (2016) reported that teachers demonstrated readiness, professional practices, and teaching efficiency in handling different teaching areas. However, Mekonnen and Golga (2023) identified deteriorating ethical professional practices, including tardiness, absenteeism, poor teacher-student communication, and lack of transparency in assessment. Desimone and Garet (2015) emphasized content focus, active learning, coherence, sustained duration, and collective participation as best practices for teacher professional development. Professional attributes also contribute to teacher effectiveness. Saban (2015) found a connection between professional practices and professional attributes, while Charles (2019) emphasized relationship-based attributes as important characteristics of effective teachers. Suico (2021) reported a very high correlation between teacher attributes, self-efficacy, and classroom management. Barnett (2019) also found a clear correlation between high-quality teaching and instructional strategies such as student engagement and higher-order questioning.

Teaching skills are part of teachers' professional growth and effectiveness. Gultom et al. (2020) found that teaching skills such as reinforcement, questioning, variation, explanation, small group discussion, management, and individual teaching increase student learning interest. Tobgay (2021) emphasized the importance of motivational skills in facilitating learning. Kim et al. (2019) showed that enhancing 21st century teaching skills supports feedback, reflective practice, and instructional improvement. Pambudi and Gunawan (2020) found that leadership, supervision, and teaching skills

significantly influence teacher effectiveness. Adeyemi (2019) identified a correlation between teaching effectiveness and students' academic learning, while Nemiño (2023) found that student performance may be predicted by teacher effectiveness, including gender. However, Muyodi and Kamya (2022) indicated a non-significant relationship between teacher effectiveness and students' performance in Physics. Aina et al. (2015) identified professional development, punctuality, and interpersonal relationships as essential elements of teacher effectiveness.

Globally, education systems recognize that teacher quality affects learner outcomes. The experiences of high-performing education systems such as Canada, Poland, Finland, Korea, and Singapore show that learners benefit from teachers with strong skills and competence (Partelow et al., 2017). Nationally, the Philippines' low performance in the 2018 Program for International Student Assessment underscores the need to strengthen the quality of instruction in reading, mathematics, and science (Ambag, 2018). Locally, the problem is reflected in Dumanjug District I and II, Dumanjug, Cebu, where learners' Science and Mathematics performance requires attention. The study responds to this local need by examining how teacher-related factors predict learners' academic performance during the 2024–2025 school year. It also supports the need for professional development programs that can help science teachers improve instruction and contribute to better learner performance.

The study is anchored on Behaviorism and Social Constructivism. Behaviorism, associated with John Watson and B.F. Skinner as cited by Faryadi (2007), explains learning through observable behavior, stimulus, response, reinforcement, and environmental conditions. In classroom practice, this means learners respond to the learning environment, activities, and instructional stimulus provided by the teacher (Faryadi, 2007). Plotkin (2003) stated that learning is exhibited through observation of the surroundings, while Schlinger (2005) emphasized that problems may be addressed by understanding human behavior and the environment. Rewards may be positive or negative in the learning process (Faryadi, 2007; Baumgartner et al., 2003). Wegner (2005) noted that individuals learn from the environment, and learning occurs when behavioral and disciplinary conditions are followed (Crow & Tian-Ming, 2006). Behaviorism focuses on observable and measurable behaviors (Miltenberger, 2001). In relation to teaching, the teacher's ability to create a favorable learning environment affects how learners respond, answer questions, solve problems, and acquire knowledge. Piopiunik et al. (2014) showed a positive and strong association between classroom environment and learners' behavior, while Darling-Hammond (2000) emphasized the importance of teacher strategies that fit learners' needs.

Social Constructivism, associated with Lev Vygotsky as cited by Akpan et al. (2020), views learning as a collaborative process involving learners, teachers, peers, and classroom interaction. Teachers must create active environments that promote understanding through collaborative tasks (Akpan, 2002). Kapur (2018) noted that knowledge may be gained through group discussion, instructional aids, and interaction. This theory explains how learners interpret and construct meaning through experiences and prior knowledge (Schwandt, 2001; Creswell, 2013). Classroom interaction helps develop and investigate new information (Howell and Annansingh, 2013), while the teacher's knowledge and resources remain essential in active classroom discussion (Gilakjani et al., 2012). Kussmaul and Pirmann (2021) and Kanno (2018) emphasized that learners construct knowledge through prior ideas and environmental interaction. Constructivist learning encourages learners to create meaning rather than merely memorize concepts (Fleury & Garrison, 2014). Learners clarify knowledge through questions and direct instruction (Bybee, 2009), elaborate new information through activities (Aljohani, 2017), and receive evaluation through feedback and assessment (Singh & Yaduvanshi, 2015). Teachers who apply constructivist principles encourage critical thinking, feedback, learner engagement, dialogue, collaboration, and interactive techniques (Kutay et al., 2012; Taylor, 2018; Al-Qaysi, Mohamad-Nordin, & Al-Emran, 2020).

The legal and conceptual bases also include SDG 4 – Quality Education (United Nations, n.d.) and the Philippine Professional Standards for Teachers under DO 42, s. 2017 (Department of Education, 2017) on the National Adoption and Implementation of the Philippine Professional Standards for Teachers. SDG4 promotes equitable and quality education for all learners (United Nations, n.d.), while DepEd initiatives such as Alternative Learning System, Indigenous Peoples Education, Digital Rise Program, and Last Mile Schools Program support inclusive and accessible education (Department of Education, 2019). Department of Education (2017) emphasizes professional standards, teacher development, and quality teaching as pathways to quality learning. The conceptual model links teachers' professional knowledge, professional practices, professional attributes, and teaching skills to learners' academic performance. Professional knowledge involves content mastery, pedagogical content knowledge, and science curriculum knowledge. Good teachers possess subject matter knowledge, pedagogical strategies, motivation, teaching skills, and experience (Sadler et al., 2013; Keller et al., 2014; Dorman, 2001). Teachers must also update their knowledge through practice and research (Révai, 2020). Professional practices include planning, instructional strategies, assessment, interaction, and classroom management that help learners become independent and strategic (Blazar & Kraft, 2017; Jimenez, 2020). Professional attributes include teacher characteristics that influence classroom engagement and academic achievement (Enwelim, 2016; Radmacher & Martin, 2001; Salfi & Saeed, 2007). Teaching skills include the use of content sustainability, organization and clarity, activities, questioning, interaction, media, and individual style to support learner understanding (Williams, 2003; Charanjit, 2014; Ehindero & Ajibade, 2000).

Although many studies emphasize the role of teacher quality in student achievement, limited empirical research has examined how teachers' professional knowledge, professional practices, professional attributes, and teaching skills collectively predict elementary learners' academic performance, particularly in the Dumanjug district (Quibrar et al., 2024; Melchor et al., 2025; Bibon, 2022). Existing studies often focus on isolated teacher-related factors rather than developing a comprehensive regression model that explains the predictive influence of multiple dimensions of teacher effectiveness. The literature also shows mixed findings. While several studies support significant relationships among teacher competence, teaching skills, professional practice, attributes, and learner achievement, others suggest that classroom environment, teaching skills, or teacher effectiveness may not always significantly predict academic performance, as reflected in Sultan and Shafi (2014), Norwani et al. (2017), Nazari & Far (2019), and Muyodi and Kamya (2022). These inconsistencies justify the need for a localized regression model that can determine which teacher-related factors are most relevant to learners' academic performance in the study context. Thus, this study aims to develop a regression model that predicts elementary learners' academic performance based on teachers' professional knowledge, professional practices, professional attributes, and teaching skills. It also seeks to provide evidence for a faculty development program that can guide school administrators, teachers, and education stakeholders in strengthening science instruction.

This study is most directly aligned with SDG 4 – Quality Education. The study supports SDG4 by addressing teacher effectiveness as a pathway to improving learners' academic performance, especially in science education. It focuses on professional knowledge, professional practices, professional attributes, and teaching skills, all of which contribute to quality teaching and better learning outcomes. The study also reflects the SDG4 emphasis on equitable, inclusive, and quality education, particularly through the role of teachers in supporting diverse learners and improving classroom instruction (United Nations, n.d.; Department of Education, 2019). The study also supports educational sustainability because it aims to strengthen teacher capacity and improve learner performance through evidence-based professional development. By developing a regression model, the research provides a basis for identifying teacher-related factors that require support, training, and institutional intervention. This aligns with the purpose of Department of Education (2017), which promotes professional standards and continuous development for teachers.

The study contributes mainly to educational and institutional sustainability. Educationally, it supports long-term improvement in science learning by identifying teacher-related factors that influence learners' academic performance. Stronger professional knowledge, better classroom practices, positive professional attributes, and improved teaching skills can help learners acquire scientific knowledge, develop problem-solving abilities, and improve academic outcomes. Institutionally, the study provides school administrators and education leaders with evidence for designing faculty development programs. The regression model may help identify areas where teachers need training, mentoring, and professional support. This makes the study useful for planning sustainable school improvement initiatives that are aligned with teacher standards, classroom needs, and learner performance. The study also contributes to community sustainability because improved teacher effectiveness can support learners' holistic development and future readiness. When learners receive quality science instruction, they are better prepared to participate in society, pursue further education, and contribute to community development. The study has limited but relevant connection to technological and digital sustainability because the literature recognizes the role of media, technology integration, and the Digital Rise Program in improving teaching and learning (Preeti, 2014; Ali et al., 2020; Ali et al., 2022; Department of Education, 2019). Overall, the study supports sustainable improvement in science education through teacher development, learner achievement, and evidence-based institutional planning.

2. Material and methods

2.1 Research Design

The study employed a quantitative method of data gathering. Adapted questionnaires developed and validated by SEI-DOST & UP NISMED (2011) were used to collect data on the effectiveness of science teachers in handling science classes, particularly in terms of professional knowledge, professional practices, professional attributes, and teaching skills. Learners' academic performance was measured through their Grade Point Average and class Mean Percentage Score. These academic performance indicators were correlated with teacher effectiveness to determine possible relationships among the variables. The computation of significant relationships and the development of the faculty development program were also conducted quantitatively.

2.2 Locale of the Study

The study was conducted in the identified schools of Dumanjug District I and II, Dumanjug, Cebu, under the Department of Education Division of Cebu Province. The participating schools included Balaygtiki ES, Lamak ES, Panlaan ES, Manlapay ES, Tangil ES, Masa ES, Kanghalo ES, Tubod Duguan ES, Doldol ES, Bulak ES, Tubod Bitoon ES, Matalo ES, Bitoon ES, Kanghumaod ES, Kanyuko ES, and Cambanog ES. Dumanjug is a first-class municipality in the province of Cebu, located approximately 73 kilometers south of Cebu City. It has a land area of 8,544 hectares and is situated between

Barili in the north and Ronda in the south, with Sibonga and Argao on the eastern border and Tañon Strait on the western side. The municipality is composed of 37 barangays, including the areas covered by the study.

2.3 Respondents of the Study

The respondents were science teachers and learners from the identified schools in Dumanjug District I and II, Dumanjug, Cebu. The study involved 130 science teachers and 1,300 learners, for a total of 1,430 respondents. Grade 3 was represented by 20 teachers and 200 learners, Grade 4 by 40 teachers and 400 learners, Grade 5 by 40 teachers and 400 learners, and Grade 6 by 30 teachers and 300 learners. Each teacher-respondent was counter-validated by 10 learners who answered the corresponding learner questionnaire.

2.4 Sample and Sampling Procedure

Random sampling was used to select the teacher and learner respondents needed for the study. The sample included science teachers from Grades 3 to 6 and their corresponding learner-validators. The learner respondents served as counter-validators of teacher responses to strengthen the assessment of teacher effectiveness in relation to science instruction.

2.5 Research Instrument

The study utilized survey questionnaires to collect the needed data. To assess the levels of science teachers' professional knowledge, professional practices, and professional attributes, the questionnaire developed and validated by SEI-DOST & UP NISMED (2011) was used. The section on Professional Knowledge assessed science content, pedagogical content knowledge, and science curriculum. The section on Professional Practices measured six practices related to effective and quality science instruction. The section on Professional Attributes assessed the traits science teachers need to adapt to change and foster professional growth. To assess teaching skills, a questionnaire from National Research Council (2003) was used. It covered seven parameters, namely Sustainability of Content, Organization and Clarity, Activities, Use of Questions, Interaction, Use of Media, and Individual Style. Responses were interpreted based on SEI-DOST & UP NISMED (2011) under the Framework for Philippine Science Teacher Education. The instrument used the performance categories Certified Science Mentor, Master Science Teacher, Emerging Professional Science Teacher, and Neophyte Science Teacher. The same instrument was also used in the study of Laguatan and Abad (2019) and in Cadiza (2020), which assessed 21st century skills of science teachers using SEI-DOST & UP NISMED (2011). Each questionnaire item was assessed using a four-point Likert scale: Strongly agree (4), Agree (3), Disagree (2), and Strongly Disagree (1). For professional knowledge, professional practices, professional attributes, and teaching skills, the interpretation was based on the rubrics of SEI-DOST & UP NISMED (2011). A mean range of 3.25–4.00 indicated Strongly Agree or Certified Science Mentor, 2.50–3.24 indicated Agree or Master Science Teacher, 1.75–2.49 indicated Disagree or Emerging Science Professional Teacher, and 1.00–1.74 indicated Strongly Disagree or Neophyte Science Teacher. Learners' academic performance was interpreted using the grading system adopted from Department of Education (2015) through DO 8, s. 2015, where 90–100% indicated Outstanding, 85–89% indicated Very Satisfactory, 80–84% indicated Satisfactory, 75–79% indicated Fairly Satisfactory, and below 75% indicated Did Not Meet Expectation.

2.6 Data Gathering Procedure

The researcher first requested approval from the District Supervisor of Dumanjug District through a transmittal letter and secured a Notice to Proceed certificate from the Local Review Ethics Committee before data collection. After approval was granted, the researcher explained the purpose of the study and its relevance to the teaching-learning process, particularly in science. The questionnaires were then distributed to the science teacher-respondents, and another set was given to the learner-respondents for counter-validation. The completed questionnaires were collected from the respondents' respective offices or rooms. Since the teachers had records of class Mean Percentage Score, these data were also obtained from them. After collecting all necessary data, the researcher sorted, assessed, interpreted, and analyzed the information to determine the findings of the study.

2.7 Data Analysis Techniques

The gathered data were collected, classified, tabulated, computed, analyzed, and interpreted. Weighted mean was used to assess the level of teachers' effectiveness in terms of professional knowledge, professional practices, professional attributes, and teaching skills. Percentage was used to describe learners' Grade Point Average and class Mean Percentage Score. Pearson-r was used to determine the significant relationship between teacher-related factors and learners' academic performance. Pearson-r was also applied to measure the significant relationship among the parameters of teacher effectiveness.

2.8 Ethical Considerations

The study observed ethical procedures by securing approval through a transmittal letter and obtaining a Notice to Proceed certificate from the Local Review Ethics Committee before the conduct of data gathering. The respondents were informed about the purpose of the study and how it would contribute to the improvement of science teaching and learning. The information collected from teachers and learners was handled with confidentiality and privacy.

3. Results and Discussion

3.1 Science Teachers' Professional Knowledge

3.1.1 Science Content

The results showed that science teachers were rated as Master Science Teacher in science content, with a composite mean of 3.12 from teachers and 3.03 from learners. The highest teacher rating was on identifying and addressing students' science misconceptions and textbook misconceptions, with a weighted mean of 3.80, while the lowest was on mastery of science concepts that serve as enrichment topics, with a weighted mean of 2.52. Learners similarly rated teachers highest in addressing misconceptions, with a weighted mean of 3.56, and lowest in mastery of enrichment concepts, with a weighted mean of 2.63. These findings indicate that science teachers were effective in explaining science content, clarifying misconceptions, and relating science to technology, although there was still a gap in full mastery of enrichment topics. Al Sultan et al. (2018) emphasized that teachers should be fully equipped in science content and teaching methods because scientific literacy and knowledge increase teacher self-efficacy and learners' academic performance. Catalano et al. (2019) stressed the importance of recognizing gaps in content knowledge so that these can be remedied before being transferred to learners. Fletcher-Wood (2018) also highlighted that feedback supports learners' knowledge and confidence, while Jeschke et al. (2019) affirmed that teachers' content knowledge and strategies help relay information appropriately and accurately.

3.1.2 Pedagogical Content Knowledge

The teacher-respondents rated their pedagogical content knowledge as Master Science Teacher, with a composite mean of 3.03, while learner-respondents rated them as Certified Science Mentor, with a composite mean of 3.40. Teachers rated themselves highest in knowing how to engage learners in discussion, with a weighted mean of 3.80, and in understanding varied forms of formative and summative assessment, with a weighted mean of 3.77. The lowest rating was on understanding the variety of ICT, with a weighted mean of 2.38. Learners rated teachers highest in having a strong subject background and developing learners' deeper understanding, with a weighted mean of 3.53, while the lowest was still positively rated in terms of engaging learners in discussion, with a weighted mean of 3.26. The findings show that teachers had strong pedagogical competence in assessment, discussion, and learner engagement, but had limited mastery of broader ICT tools beyond common classroom technologies. Feng (2021) defined pedagogical content knowledge as teachers' understanding of analogies, illustrations, explanations, and demonstrations that make subject matter teachable. Skedsmo (2020) emphasized that pedagogical content knowledge influences teaching and learning because it combines pedagogy and content. Mensah et al. (2023) emphasized the importance of ICT usage in improving learners' performance, especially among 21st century learners. Suglo et al. (2023) found a significant correlation between pedagogical content knowledge and learners' academic performance, confirming the value of appropriate techniques in delivering accurate content.

3.1.3 Science Curriculum

The teacher-respondents rated science curriculum knowledge as Master Science Teacher, with a composite mean of 2.67, while learners rated teachers as Certified Science Mentor, with a composite mean of 3.46. Teachers rated themselves highest in knowing the characteristics of good science textbooks and instructional materials, with a weighted mean of 2.74, followed by knowledge of laboratory equipment and tools, with a weighted mean of 2.71. The lowest teacher rating was on understanding the different science education needs of all learners and those interested in scientific careers, with a weighted mean of 2.58. Learners rated teachers highest in understanding these differentiated science education needs, with a weighted mean of 3.53, and lowest in knowing laboratory equipment, tools, and instructional materials, with a weighted mean of 3.34. The results imply that teachers understood the science curriculum, instructional materials, and laboratory tools, although attention to learners' varied science education needs remained an area for improvement. Soysal (2022) highlighted that science curriculum and materials are important in effective science teaching because they contain objectives, content, approaches, strategies, and competencies. Cross et al. (2020) emphasized that curriculum development should consider learners' needs, local experiences, objectives, content, and teaching strategies. Restiana and Djukri (2021) showed that learners can develop good ability in identifying laboratory equipment when teachers explain tools properly. Boukayoua et al. (2021) also emphasized that learners' perception of science is vital to learning quality and future engagement.

3.2 Science Teachers' Professional Practices

3.2.1 Designing Sound Teaching and Learning Experiences

The findings showed that teachers were rated as Master Science Teacher in designing sound teaching and learning experiences, with a composite mean of 2.66, while learners gave a composite mean of 3.23, also interpreted as Master Science Teacher. Teachers rated themselves highest in responding to learners' needs, with a weighted mean of 3.33, and lowest in using students' experiences and backgrounds in developing science concepts, with a weighted mean of 2.38. Learners rated teachers highest in using real-life contexts to make science learning meaningful, with a weighted mean of 3.36, while the lowest learner rating was still positive in terms of using students' experiences in developing science concepts. The results suggest that teachers used real-life contexts and differentiated instruction to respond to learners'

needs, but the integration of students' personal experiences into science concepts was less emphasized. Hollins (2023) recognized professional practices as knowledge-based actions applied in teaching, while Mekonnen & Golga (2023) described them as part of professionalism and responsibility in providing a healthy and safe learning environment. Galman and Rosario (2021) emphasized that learning becomes easier when real-life situations are simulated, while Zens (2021) stated that differentiated learning activities increase motivation and engagement. Yalcin et al. (2017) further explained that realistic life content creates interest and helps learners connect science problems with real-life experiences.

3.2.2 Creating and Maintaining a Learner-Centered Safe Environment

The results showed that teachers were rated as Master Science Teacher in creating and maintaining a learner-centered safe environment, with a composite mean of 3.21, while learners gave a similar rating with a composite mean of 3.23. Teachers rated themselves highest in enabling students to maintain good behavior, with a weighted mean of 3.80, followed by dealing with arguments and conflicts fairly and respectfully, with a weighted mean of 3.68, and establishing warm and supportive relationships, with a weighted mean of 3.67. The lowest teacher rating was on using learner diversity as a learning resource, with a weighted mean of 2.52. Learners also rated teachers highest in maintaining good behavior, with a weighted mean of 3.83, and lowest in using learner diversity as a learning resource, with a weighted mean of 2.39. These findings indicate that science teachers established a safe, respectful, and supportive classroom environment, although differentiated use of learner diversity as a learning resource needed further strengthening. Mempin (2024) expressed that a secure and welcoming environment helps learners develop ownership, accountability, and respect despite differences in culture, religion, and background. Davis (2022) similarly highlighted that a positive and safe learning environment helps students feel valued, supported, and included, increasing productivity, creativity, and motivation.

3.2.3 Engaging Students in Scientific Practice

Teachers were rated as Master Science Teacher in engaging students in scientific practice, with a composite mean of 2.75, while learners also rated them as Master Science Teacher, with a composite mean of 3.21. Teachers rated themselves highest in developing students' curiosity and openness to new ideas, with a weighted mean of 3.56. Their lowest rating was on enabling students to control technological tools, with a weighted mean of 2.33, and providing opportunities to use technology in authentic contexts, with a weighted mean of 2.43. Learners also rated teachers highest in developing curiosity and openness to new ideas, with a weighted mean of 3.48, while lower ratings were related to modeling practices and technology use. The results imply that teachers were effective in encouraging curiosity, inquiry, investigation, observation, and hypothesis-making, but technology-based scientific practice remained limited. Inkinen et al. (2020) described engagement in scientific practice as a means for learners to understand the world and perform well in science. Lager and Lavonen (2023) highlighted that science education should not only teach concepts but also involve learners actively in scientific practices so theories and assumptions become meaningful.

3.2.4 Extending Students' Understanding of Ideas and Concepts

The results showed that teachers were rated as Master Science Teacher in extending students' understanding of ideas and concepts, with a composite mean of 2.86, while learners gave a composite mean of 2.90, also interpreted as Master Science Teacher. Teachers rated themselves highest in building on students' prior knowledge and incorporating it into science teaching, with a weighted mean of 3.33. The lowest teacher rating was on helping learners understand that scientific language has precise meanings that may differ from everyday usage, with a weighted mean of 2.50. Learners rated teachers highest in using unplanned learning opportunities and maintaining high engagement through flexible approaches, both with weighted means of 3.19, while the lowest learner rating was on using examples to show how science changes over time. These findings show that science teachers used prior knowledge, flexible strategies, and learning opportunities to deepen understanding, but scientific vocabulary and the historical development of scientific ideas needed further emphasis. Cardino & Ortega-Dela Cruz (2020) cited that flexibility and creativity are needed to expand learners' understanding according to their needs. Gerges (2022) also explained that science teaching requires instructional planning that engages learners in cognitively challenging inquiry, questioning, exploration, and evidence-based explanation.

3.2.5 Building Students' Self-Confidence and Capacity to Make Informed Decisions

The findings showed that teachers were rated as Master Science Teacher in building students' self-confidence and capacity to make informed decisions, with a composite mean of 2.57, while learners gave a composite mean of 2.75, also interpreted as Master Science Teacher. Teachers rated themselves highest in exposing students to varied learning situations that make science part of daily life, with a weighted mean of 2.89. The lowest teacher rating was on increasing students' understanding of how current decisions affect the future directions of Science, Technology, and Society, with a weighted mean of 2.33. Learners rated teachers highest in using strategies that develop divergent thinking, with a weighted mean of 3.23, and lowest in encouraging students to read newspaper articles about science, with a weighted mean of 2.30. The results indicate that teachers helped learners connect science with daily life and divergent thinking, but there were gaps in encouraging science-related reading and linking current decisions to future science and technology issues. Akbari & Sahibzada (2020) defined self-confidence as learners' belief or trust in completing tasks successfully. Muhibbuddin et al. (2020) expressed

that self-confidence helps learners believe in their capability, become curious and participative, ask questions, share opinions, and take initiative in learning.

3.2.6 Using Assessment Strategies Consistent with Learning Goals

The results showed that teachers were rated as Certified Science Mentor in using varied strategies consistent with learning goals, with a composite mean of 3.63, while learners also rated them as Certified Science Mentor, with a composite mean of 3.31. Teachers rated themselves highest in using assessment as part of evaluating the quality of their own work, with a weighted mean of 3.85, followed by keeping careful records of students' progress, with a weighted mean of 3.83. The lowest teacher rating was on using an extensive repertoire of formal and informal assessment strategies, with a weighted mean of 3.29. Learners rated teachers highest in recognizing different reporting requirements of parents and authorities, with a weighted mean of 3.46, while the lowest learner rating was on self and peer assessment strategies, with a weighted mean of 3.11. The findings imply that teachers were highly effective in assessment, record keeping, and monitoring learning progress, although self-assessment, peer assessment, and varied assessment strategies may still be expanded. Costa et al. (2020) defined assessment as a process that supports engagement, self-regulation, and productive teaching and learning. Villagra-Arnedo et al. (2018) claimed that assessment should focus on learners, provide truly formative judgment, and generate data on learners' progress, strengths, and weaknesses.

3.3 Science Teachers' Professional Attributes

3.3.1 Analyzing, Evaluating, and Refining Teaching Practices

Teachers were rated as Master Science Teacher in analyzing, evaluating, and refining teaching practices, with a composite mean of 2.75, while learners gave a higher composite mean of 3.09, also interpreted as Master Science Teacher. Teachers rated themselves highest in using various ways to gain professional growth, with a weighted mean of 3.18, while the lowest rating was on developing lifelong learning with risk-taking and flexibility, with a weighted mean of 2.50. Learners observed that teachers identified strengths and weaknesses and improved teaching strategies for academic learning. These findings show that science teachers engaged in professional growth through graduate studies, seminars, training, self-assessment, and refinement of teaching practices, although shifting fully to new concepts and practices remained a challenge. Aloro (2024) conveyed that teachers are vital role models who influence learners and should develop effective attributes in the learning environment. Qamar et al. (2023) defined teaching practices as performances requiring professional, cognitive, and rational selection with self-regulation. Rauf et al. (2022) revealed that sound teaching practices influence learners' achievement, motivation, and willingness to learn.

3.3.2 Working with Other Teachers and Professional Communities

Teachers were rated as Master Science Teacher in working with other teachers and professional communities, with a composite mean of 3.06, while learners gave a composite mean of 3.03, also interpreted as Master Science Teacher. Teachers rated themselves highest in acknowledging that seeking and giving collegial advice were not signs of incompetence, with a weighted mean of 3.75, and in helping colleagues' professional growth, with a weighted mean of 3.33. The lowest rating was on being a team player, with a weighted mean of 2.43. Learners rated teachers highest in helping other teachers and being engaged in professional development, both with weighted means of 3.26.

The results suggest that science teachers valued collegial advice, professional development, and collaboration, although implementation of classroom work and reports was still often done individually. Collaborative practices allowed teachers to share experiences, approaches, and knowledge useful in teaching science. Teachers learn from each other through working collaboratively (Lecat et al., 2019). Nguyen & Ng (2020) indicated that collaboration is an essential tool for school improvement because it builds personal, interpersonal, and organizational capacity and strengthens the culture of professionalism.

3.4 Science Teachers' Teaching Skills

3.4.1 Sustainability of Content

Teachers were rated as Certified Science Mentor in sustainability of content, with a composite mean of 3.38, while learners also rated them as Certified Science Mentor, with a composite mean of 3.50. Teachers rated themselves highest in applying differentiated instruction, when necessary, with a weighted mean of 3.65, and lowest in integrating and utilizing ICT during the lesson, with a weighted mean of 3.20. Learners rated teachers highest in distinguishing factual material from opinions, with a weighted mean of 3.68, and lowest in ICT integration, with a weighted mean of 3.23. The findings indicate that teachers sustained science content through differentiated instruction, examples from learner experiences, integration of literacy and numeracy, and use of appropriate materials, but ICT-based content delivery remained limited. Gultom et al. (2020) emphasized that teachers need teaching skills to manage the classroom and achieve learning goals. Aydın & Mıhladız Turhan (2023) linked sustainability of content with teachers' ability to understand, cycle, and manifest knowledge in the classroom. Galimova et al. (2023) emphasized content as an essential ingredient in learners' growth and success.

3.4.2 Organization and Clarity

Teachers were rated as Certified Science Mentor in organization and clarity, with a composite mean of 3.34, while learners rated them as Master Science Teacher, with a composite mean of 3.22. Teachers rated themselves highest in asking questions periodically to determine whether too much or too little information was being presented, with a weighted mean of 3.55, followed by arranging and discussing content systematically, with a weighted mean of 3.49. The lowest teacher rating was on stating relationships among various explicit ideas, with a weighted mean of 3.20. Learners rated teachers highest in stating the purpose of the lesson and using simple examples, both with weighted means of 3.74, while the lowest was on explaining relationships among explicit ideas, with a weighted mean of 3.06. The results show that science teachers were strong in presenting objectives, organizing lessons, asking questions, and giving clear examples, although linking explicit ideas across topics needed improvement. Hall (2019) described organization and clarity as strategies that promote learning by presenting content clearly and understandably. Hall (2019) further emphasized that organization and clarity support cognitive learning by helping learners connect prior and new knowledge and encourage affective learning through positive classroom interaction.

3.4.3 Activities

Teachers were rated as Certified Science Mentor in activities, with a composite mean of 3.42, while learners gave a composite mean of 3.61, also interpreted as Certified Science Mentor. Teachers rated themselves highest in giving clear instructions for activities, with a weighted mean of 3.64, and lowest in making students the center of activity debriefing, with a weighted mean of 3.25. Learners rated teachers highest in giving sufficient time to complete activities, while the lowest rating was still positive and referred to students being the center of debriefing. The findings imply that science teachers were highly effective in organizing activities, giving instructions, providing time, and using learner-centered tasks. Beymer et al. (2021) specified that activities include class discussion, laboratory activities, individual work, and group work. Mon (2019) emphasized that activities may produce positive or negative consequences depending on how they are given; proper activities increase motivation and understanding, while poorly matched activities may cause anxiety, boredom, and low academic performance.

3.4.4 Use of Questions

Teachers were rated as Certified Science Mentor in the use of questions, with a composite mean of 3.47, while learners also rated them as Certified Science Mentor, with a composite mean of 3.56. Teachers rated themselves highest in repeating answers when necessary so the class could hear, with a weighted mean of 3.65, and lowest in discussing very difficult and time-consuming questions before or after class or during office hours, with a weighted mean of 3.26. Learners rated teachers highest in addressing questions to individual students and the group, with a weighted mean of 3.74, while the lowest rating was on asking students to clarify questions, when necessary, with a weighted mean of 3.31. The results show that teachers used questioning effectively to stimulate interest, comprehension, participation, and critical thinking. They asked questions, gave learners time to think, rephrased difficult questions, repeated answers, and addressed both individuals and groups. Questioning was important because it built learning and developed learners' thinking through questions asked during instruction (Shanmugavelu et al., 2017). Pandey (2022) stated that questioning is a good technique for involving students, developing classroom conversation, critical thinking, and language skills useful in real-life communication.

3.4.5 Interaction

Teachers were rated as Certified Science Mentor in interaction, with a composite mean of 3.55, while learners gave a composite mean of 3.54, also interpreted as Certified Science Mentor. Teachers rated themselves highest in responding to signs of puzzlement, boredom, curiosity, and other learner behaviors, with a weighted mean of 3.60, while the lowest rating was on maintaining eye contact, with a weighted mean of 3.45. Learners rated teachers highest in using facial and body movements that did not contradict speech or intention, with a weighted mean of 3.68, while the lowest was on noticing and responding to learner signals. The findings indicate that teachers mastered interaction skills through verbal and non-verbal communication, listening, eye contact, sensitivity to learners' needs, and classroom dialogue. Tang (2021) defined classroom interaction as conversational exchange between teacher and learners, including questions and classroom communication. Interaction was a collaborative exchange of ideas leading to enhanced learning (Tiwari, 2021).

3.4.6 Use of Media

Teachers were rated as Certified Science Mentor in use of media, with a composite mean of 3.27, while learners rated them as Certified Science Mentor, with a composite mean of 3.39. Teachers rated themselves highest in using audio-visual materials to assist comprehension, with a weighted mean of 3.46, and lowest in using audiovisual devices and ICT devices, with weighted means within the Agree range. Learners also rated teachers highest in using audio-visual materials, with a weighted mean of 3.68, and lowest in using ICT devices, with a weighted mean of 3.11. The results show that teachers used media effectively through slides, videos, images, and audio-visual materials, but broader ICT device use and interactive digital tools were limited. Marini et al. (2022) characterized media use as a learning process that improves learning quality and develops 21st century skills. Sondakh et al. (2021) emphasized that learning media is effective and efficient when used appropriately and when it makes learning interesting and enjoyable inside and outside the classroom.

3.4.7 Individual Style

Teachers were rated as Certified Science Mentor in individual style, with a composite mean of 3.43, while learners gave a composite mean of 3.42, also interpreted as Certified Science Mentor. Teachers rated themselves highest in raising or lowering the voice for variety and emphasis, with a weighted mean of 3.56, while the lowest ratings were on giving speeches that were neither too formal nor too casual and maintaining an appropriate speech rate, both with weighted means of 3.30. Learners rated teachers highest in voice variation, with a weighted mean of 3.82, and lowest in the item related to teacher presentation and approachability, with a weighted mean of 3.28. The findings suggest that teachers' individual style supported learning through voice modulation, appropriate speech, pacing, professional presence, and classroom communication. Yoshida et al. (2024) explained that teachers have their own teaching style, including approaches to teaching, learning, problem-solving, decision-making, and professional growth. Inayat & Ali (2020) highlighted the importance of teachers' style and the environment they create in the classroom, showing the need to develop a teaching style centered on learners' holistic development.

3.5 Overall Effectiveness of Science Teachers

The overall results showed that teachers rated themselves as Master Science Teacher in professional knowledge, with a composite mean of 2.94; professional practices, with a composite mean of 2.95; and professional attributes, with a composite mean of 2.91. They rated themselves as Certified Science Mentor in teaching skills, with a composite mean of 3.41. Learners rated teachers as Certified Science Mentor in professional knowledge, with a composite mean of 3.30, and teaching skills, with a composite mean of 3.46. Learners rated teachers as Master Science Teacher in professional practices, with a composite mean of 3.11, and professional attributes, with a composite mean of 3.06. The findings indicate that science teachers were generally effective in knowledge, practices, attributes, and teaching skills. They demonstrated content mastery, appropriate strategies, positive classroom behavior, professional collaboration, and strong delivery of instruction. Ngan et al. (2021) emphasized that teachers' knowledge improves the quality of teaching. Hollins (2023) stressed that teaching practices require a strong knowledge base and learning experiences to respond to diverse learners. Aloro (2024) emphasized the teacher's role in shaping learners through professional attributes, while Gultom et al. (2020) stressed that teaching skills increase students' interest in learning and support classroom readiness and competency attainment.

3.6 Learners' Academic Performance

3.6.1 Grade Point Average

The results showed that most learners' science Grade Point Average fell under Very Satisfactory, with 73 or 48% of the respondents in the 85–89 range. This was followed by Satisfactory, with 48 or 32%, Outstanding, with 25 or 17%, Fairly Satisfactory, with 3 or 2%, and Did Not Meet Expectation, with 1 or 1%. These results indicate that most learners achieved a notable level of academic performance in science. The findings imply that teachers' efforts in using differentiated instruction and varied approaches were reflected in learners' Grade Point Average. Papadogiannis et al. (2023) described GPA as a measure of overall performance using one evaluation tool that allows equal and uniform assessment of learners. Mehmetaj and Alili (2021) emphasized the benefit of GPA because of its simplicity and objectivity. Verostek et al. (2021) also noted that GPA may be connected to professional success because it monitors learners' capability through simple measurement.

3.6.2 Class Mean Percentage Score

The results showed that most class Mean Percentage Scores were also Very Satisfactory, with 62 or 41% in the 85–89 range. This was followed by Satisfactory, with 55 or 37%; Outstanding, with 27 or 18%; Fairly Satisfactory, with 5 or 3%; and Did Not Meet Expectation, with 1 or 1%. Overall, the class Mean Percentage Score was noteworthy because most respondents passed the standard level for science performance. The findings suggest that class Mean Percentage Score provided useful evidence of teacher effectiveness and learner achievement in science. It also reflected the teachers' dedication and efforts in meeting science competencies. Raganit (2021) described Mean Percentage Score as baseline data for improving lesson delivery, selecting learning resources, planning school improvement, and adjusting teaching strategies. Raganit (2021) also compared Mean Percentage Score to data-driven decision-making because it supports strategic evaluation and interpretation of learner performance.

3.7 Significant Relationships Among Variables

The results showed significant relationships between teacher-related factors and learners' academic performance. Professional knowledge had a moderate positive correlation with academic performance, with an r-value of 0.402. Professional practices had the strongest positive correlation with academic performance, with an r-value of 0.627. Professional attributes also had a moderate positive correlation, with an r-value of 0.356, while teaching skills had a moderate positive correlation, with an r-value of 0.461. The relationship between professional knowledge and professional practices was also significant, with an r-value of 0.315 and p-value of 0.006. Professional knowledge and teaching skills were significantly related, with an r-value of 0.434 and p-value of 0.000. Professional practices and teaching skills were

likewise significantly related, with an r-value of 0.567 and p-value of 0.000. However, professional knowledge and professional attributes were not statistically significant, with an r-value of 0.177 and p-value of 0.125. Professional practices and professional attributes were also not statistically significant, with an r-value of 0.127 and p-value of 0.276. Professional attributes and teaching skills had a very weak and non-significant relationship, with an r-value of 0.097 and p-value of 0.402. These findings indicate that teachers' professional knowledge, professional practices, professional attributes, and teaching skills influenced learners' academic performance, with professional practices showing the strongest relationship. The results also show that knowledge, practices, and teaching skills were connected, while professional attributes did not strongly influence the other effectiveness parameters. Cubero (2022) concluded that effective teaching is complex and requires quality values, skills, content knowledge, planning, communication, classroom management, realistic goals, professionalism, understanding, and kindness. Overall, the findings suggest that teacher effectiveness is shaped by the combined strength of content knowledge, teaching practices, professional attitude, and instructional skills, all of which contribute to learners' academic success in science.

4. Conclusion & Recommendations

Based on the results of the study, science teachers demonstrated effectiveness in professional knowledge, professional practices, professional attributes, and teaching skills, with teacher and learner assessments generally classifying them as Master Science Teacher or Certified Science Mentor. Learners' academic performance in science, based on Grade Point Average and class Mean Percentage Score, was mostly Very Satisfactory. The results further showed that professional knowledge, professional practices, professional attributes, and teaching skills were positively related to learners' academic performance, with professional practices showing the strongest relationship. Therefore, the ability of teachers to handle science instruction, manage the classroom, and serve as mentors, guides, facilitators, and managers inside and outside the classroom contributed to learners' academic success, particularly by strengthening their interest and engagement in science.

Based on the findings, the study recommends the use of a regression model to identify the extent to which teachers' professional knowledge, professional practices, professional attributes, and teaching skills affect learners' academic performance in science. Since teacher effectiveness influences learners' outcomes, science teachers need to continue developing their competence and skills to improve learning results. The study also recommends a development plan to enhance science teachers' effectiveness in classroom instruction by strengthening their knowledge, practices, attributes, and skills. This development plan may include an action plan, training design, and training matrix for In-Service Training, as well as sample lesson plans and sample science activities.

Compliance with ethical standards

The authors declare no conflict of interest. This study complied with recognized ethical standards for human-participant research by ensuring voluntary participation with informed consent, the right to withdraw without penalty, and strict confidentiality through anonymous, secure, and aggregated data handling. Given the focus on psychological well-being, procedures were non-invasive, and safeguards were observed to minimize discomfort, with guidance to appropriate support services when needed, and required institutional permissions were secured for instrument use and access to academic records.

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