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Path Analysis on Home and School Influences on STEM Learners' Biology Achievement

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ABSTRACT

This study examined the pathways through which home and school influences affect the Biology achievement of Grade 12 senior high school learners. Using a quantitative, descriptive–correlational research design, data were collected from senior high school students through validated survey instruments measuring home factors (parental education, parental support, home educational resources, parenting style, family interaction, and family income) and school factors (teachers' educational attainment, teachers' years of experience, school resources, and peer interaction). Learners' Biology achievement was measured using a standardized Biology summative test. Structural equation modeling (SEM) was employed to analyze the direct effects of home and school variables on Biology achievement. Descriptive results indicated that learners generally experienced fair to good levels of parental support, home resources, family interaction, and school resources. Most teachers possessed graduate-level education, and peer interaction was rated as good. Biology achievement was concentrated at the satisfactory level, with few learners attaining outstanding performance and a considerable proportion failing to meet expectations. Findings revealed that peer interaction, parental educational attainment, teachers' years of experience, and neglectful parenting style exerted significant direct effects on Biology achievement. In contrast, parental support, home educational resources, family interaction, family income, school resources, teachers' educational attainment, and other parenting styles showed no significant direct influence. The results suggest that by senior high school, Biology achievement is influenced more strongly by school-based social and instructional factors than by direct home conditions. Peer-supported learning and teacher experience emerged as critical contributors to students' academic performance in Biology. The study underscores the importance of strengthening classroom interactions, collaborative learning, and instructional expertise to enhance science achievement among senior high school learners.

1. Introduction

1.1 Background of the Study

The development of scientific literacy and academic achievement in Biology has become a central concern in secondary education, particularly at the senior high school level where learners are expected to engage in higher-order thinking, conceptual understanding, and scientific reasoning. Biology, as a core science subject, demands not only the memorization of facts but also the ability to analyze complex processes, interpret data, and apply scientific concepts to real-life contexts. Consequently, learners' achievement in Biology is shaped by a combination of individual, instructional, and environmental factors operating both within and beyond the classroom (Glynn & Muth, 2017).

Among these influences, home and school environments have been widely recognized as critical contexts that shape learners' academic outcomes. Ecological and sociocultural theories of learning emphasize that students' academic development is

embedded within interconnected systems, including the family, school, and peer networks (Bronfenbrenner, 2005; Vygotsky, 1978). At home, factors such as parental education, parenting style, family interaction, and access to educational resources influence learners' attitudes toward learning, study habits, and motivation (Sirin, 2005; Davis-Kean, 2005). Parents with higher educational attainment are often better equipped to provide cognitively stimulating environments and academic guidance, which can positively influence learners' achievement (Cheung & Andersen, 2017). However, research has also shown that the strength of home influences may diminish as learners progress into adolescence, when autonomy and school-based factors become more salient (Steinberg, 2001).

In the Philippine context, parental involvement is culturally valued, yet it often manifests more strongly in emotional and financial support rather than direct academic assistance, particularly in science subjects that require specialized knowledge (Bernardo, 2019; Caliwan, 2019). Economic constraints further complicate home-based learning, as many Filipino families face limitations in providing educational materials, technology, and conducive study environments (Ablaza & Francisco, 2022). While these home factors are believed to support general academic well-being, empirical evidence on their direct influence on subject-specific achievement, such as Biology, remains mixed and inconclusive.

Within the school setting, instructional quality, teacher characteristics, resources, and peer interactions play a crucial role in shaping learners' academic success. Teachers' educational attainment and years of teaching experience have been associated with instructional effectiveness, classroom management, and the use of pedagogical strategies that promote inquiry and critical thinking in science education (Darling-Hammond, 2017; Kini & Podolsky, 2016). In Biology, experienced teachers are better positioned to scaffold complex concepts, address misconceptions, and engage learners in meaningful laboratory and inquiry-based activities (Hofstein & Kind, 2012). Nevertheless, studies in the Philippines suggest that formal qualifications alone do not always translate into improved student achievement unless accompanied by sustained classroom experience and effective instructional practice (Ramirez & Bautista, 2020).

School resources, including laboratories, libraries, digital tools, and internet connectivity, are also essential components of effective science instruction. Adequate resources support experiential learning and enhance students' engagement with scientific inquiry (OECD, 2020). However, research indicates that the mere availability of resources is insufficient to improve academic outcomes unless these resources are meaningfully integrated into instruction (Austria & Valdez, 2018). In many Philippine public schools, disparities in resource quality and access continue to pose challenges to equitable science learning opportunities (Cabansag, 2020).

In addition to instructional and structural factors, peer interaction has emerged as a powerful influence on adolescent learning. Social learning theories posit that knowledge construction occurs through interaction, dialogue, and collaboration with others (Vygotsky, 1978). Positive peer relationships and collaborative learning environments have been shown to enhance motivation, conceptual understanding, and academic achievement in science subjects (Wentzel, 2017; Juvonen & Espinoza, 2015). Philippine studies similarly highlight that peer-assisted learning and group-based instruction improve learners' engagement and performance in Biology by promoting shared problem-solving and active participation (Lajom & Magno, 2019; Orbea & Bautista, 2020).

Despite extensive literature on home and school influences, there remains a gap in understanding how these factors interact to predict Biology achievement among senior high school learners, particularly using comprehensive analytical approaches such as structural equation modeling. Many existing studies examine home or school variables in isolation, limiting insights into their relative and combined effects. Moreover, empirical evidence specific to Biology achievement in the Philippine senior high school context remains limited.

Addressing this gap, the present study investigates the direct pathways of selected home and school influences on the Biology achievement of Grade 12 senior high school learners. By examining parental, familial, instructional, resource-based, and peer-related factors within a unified structural model, this study aims to provide empirical evidence that can inform instructional practices, school policies, and targeted interventions to improve science learning outcomes. Ultimately, understanding these pathways is essential in designing learning environments that effectively support learners' academic success in Biology and prepare them for higher education and science-related careers.

1.2 Objectives of the Study

The primary objective of this study was to examine the direct pathways of selected home and school influences on the Biology achievement of Grade 12 senior high school learners. Specifically, the study aimed to:

1. Determine the levels of learners' home influences in terms of:
   - 1.1 parents' highest educational attainment;
   - 1.2 parental support;
   - 1.3 home educational resources;
   - 1.4 parenting style;
   - 1.5 family interaction; and
   - 1.6 family income.
2. Determine the levels of learners' school influences in terms of:
   - 2.1 teachers' educational attainment;
   - 2.2 teachers' years of teaching experience;
   - 2.3 school resources; and
   - 2.4 peer interaction.
3. Determine the level of Biology achievement of Grade 12 senior high school learners.

4. Examine the direct effects of home-related factors (parental education, parental support, home educational resources, parenting style, family interaction, and family income) on learners' Biology achievement.
5. Examine the direct effects of school-related factors (teachers' educational attainment, teachers' years of experience, school resources, and peer interaction) on learners' Biology achievement.
6. Develop and test a structural model that explains the pathways of home and school influences on the Biology achievement of Grade 12 senior high school learners.

2. Literature Review

2.1 Home-Related Influences on Academic Achievement

The home environment plays a crucial role in shaping learners' academic outcomes. Bronfenbrenner's (2005) bioecological theory emphasizes that learners' development is influenced by interactions within their immediate environment, particularly the family. Parental educational attainment has been consistently linked to students' academic achievement, as educated parents are more likely to provide cognitive stimulation, academic guidance, and high educational expectations (Davis-Kean, 2005; Cheung & Andersen, 2017). Studies have shown that children of parents with higher educational backgrounds tend to demonstrate stronger academic performance across subject areas, including science.

Parental support is another key home-based factor influencing learning outcomes. Bernardo (2019) emphasized that parental involvement in Filipino households positively contributes to students' motivation and engagement in school tasks. However, the nature of parental support changes as learners progress to higher grade levels, with adolescents becoming more autonomous in their learning (Steinberg, 2001). This may explain why some studies report weaker or non-significant relationships between parental support and academic achievement at the senior high school level.

Home educational resources, such as books, internet access, and learning materials, also contribute to academic success by facilitating independent learning (Sirin, 2005). In the Philippine context, disparities in access to learning resources have been shown to influence students' academic outcomes, particularly in science subjects that require exposure to supplementary materials and digital tools (Cabansag, 2020). Nonetheless, access alone does not guarantee improved performance unless learners are guided in using these resources effectively.

Parenting style has likewise been associated with students' academic achievement. Baumrind (1991) identified authoritative parenting as most conducive to academic success due to its balance of responsiveness and structure. In contrast, neglectful parenting has been linked to lower academic performance and reduced school engagement (Steinberg, 2001). These findings suggest that emotional and behavioral regulation within the home environment can indirectly influence learners' academic outcomes.

2.2 School-Related Influences on Academic Achievement

School-related factors are equally influential in shaping learners' academic achievement. Teachers' educational attainment and teaching experience are often associated with instructional quality and student learning outcomes. Darling-Hammond (2017) argued that teachers with strong academic preparation and professional training are better equipped to employ effective pedagogical strategies. However, empirical evidence suggests that teaching experience, rather than academic credentials alone, has a more consistent impact on student achievement, particularly in science subjects (Kini & Podolsky, 2016).

School resources, including laboratory facilities, instructional materials, and technological infrastructure, are essential for effective science instruction. Hofstein and Kind (2012) emphasized that hands-on laboratory experiences enhance students' conceptual understanding and scientific reasoning skills. In the Philippine educational setting, inadequate school resources have been identified as persistent challenges that hinder effective science teaching and learning (Cabansag, 2020).

Peer interaction is another critical school-based factor influencing academic achievement. Vygotsky's (1978) social constructivist theory highlights the importance of social interaction in cognitive development. Peer-assisted learning and collaborative activities have been shown to improve science achievement by promoting knowledge sharing, motivation, and problem-solving skills (Lajom & Magno, 2019). Studies indicate that positive peer relationships foster academic engagement, particularly during adolescence when peer influence becomes increasingly salient (Wentzel, 2017).

2.3 Biology Achievement

Biology achievement is influenced by both cognitive and contextual factors. Biology as a discipline requires conceptual understanding, analytical thinking, and the application of scientific knowledge to real-world phenomena (Glynn & Muth, 2017). Learners often struggle with Biology due to its abstract concepts and the need for higher-order thinking skills. As such, supportive home environments and effective school conditions are essential for promoting success in Biology.

Empirical studies have demonstrated that students' Biology achievement is strongly associated with classroom interactions, instructional strategies, and opportunities for collaborative learning rather than solely with home-based factors at the senior high school level (Austria & Valdez, 2018; Orbea & Bautista, 2020). These findings suggest that as learners mature, school-related social and instructional factors may exert a stronger influence on academic outcomes than direct parental involvement.

2.4 Synthesis of the Literature

The reviewed literature highlights that both home and school influences play significant roles in shaping learners' academic achievement, although their relative impact may vary across educational levels. While home factors such as parental education and parenting style establish foundational learning conditions, school-based factors—particularly peer interaction and teacher experience—become more influential during senior high school. Despite extensive research on these variables, limited studies

have simultaneously examined the direct pathways of multiple home and school factors on Biology achievement using structural equation modeling in the Philippine context. This gap underscores the need for the present study.

3. Methodology

3.1 Research Design

This study employed a quantitative, descriptive–correlational research design using structural equation modeling (SEM) to examine the direct pathways of selected home and school influences on the Biology achievement of Grade 12 senior high school learners. The design was appropriate because the study sought to describe existing conditions and determine the relationships among multiple observed and latent variables without manipulating any of the study variables.

The descriptive component of the design was used to determine the levels of learners' home influences (parental education, parental support, home educational resources, parenting style, family interaction, and family income), school influences (teachers' educational attainment, teachers' years of experience, school resources, and peer interaction), and Biology achievement. This approach allowed for a systematic description of the characteristics and prevailing conditions of the learners' home and school environments as perceived by the respondents.

The correlational component aimed to examine the relationships between home- and school-related factors and learners' Biology achievement. Correlational research is appropriate when the objective is to identify patterns of association among variables and to determine the extent to which changes in one variable are related to changes in another, without implying causal relationships.

To capture the complex and simultaneous relationships among multiple predictors, structural equation modeling (SEM) was employed as the primary analytical technique. SEM allowed for the testing of both measurement and structural models, enabling the researcher to examine the direct effects of home and school variables on Biology achievement while accounting for measurement error. This method is particularly suitable for educational research involving latent constructs such as parental support, family interaction, school resources, and peer interaction, which cannot be measured directly through single indicators.

The use of SEM also made it possible to assess the overall fit of the proposed model to the observed data using multiple goodness-of-fit indices, providing a more robust understanding of how well the hypothesized pathways represent learners' academic experiences. By integrating descriptive statistics with SEM analysis, the research design ensured a comprehensive examination of both the levels and predictive relationships of home and school influences on Biology achievement.

3.2 Research Participants

The participants of the study were senior high school learners from selected public and private schools during the second semester of School Year 2024–2025 under the Department of Education–Division of Misamis Oriental. A purposive sampling technique was employed in selecting the respondents. Only Grade 12 learners enrolled in the Science, Technology, Engineering, and Mathematics (STEM) strand and currently taking General Biology II were included in the study.

3.3 Data Analysis

The collected data were analyzed using quantitative statistical techniques. Descriptive statistics, including the mean and standard deviation, were employed to describe the levels of learners' critical thinking skills and Biology achievement. Inferential statistical procedures were used to examine the relationships among the study variables. Content validity of the research instruments was established through expert review by specialists in the field of education. Construct validity and internal consistency were determined through factor analysis and reliability testing using Cronbach's alpha. All statistical analyses were conducted using appropriate statistical software, such as SPSS.

3.4 Ethical Considerations

Ethical principles were rigorously observed throughout the conduct of the study. The confidentiality and anonymity of the participants were ensured by securely storing all data and restricting access to authorized individuals only. Participation in the study was entirely voluntary, and respondents were clearly informed of their right to withdraw at any point without incurring any penalties or adverse consequences. In addition, the study adhered to the principle of non-maleficence by ensuring that no physical, emotional, or psychological harm was imposed on any participant.

4. Findings

4.1 Levels of learners' home influences

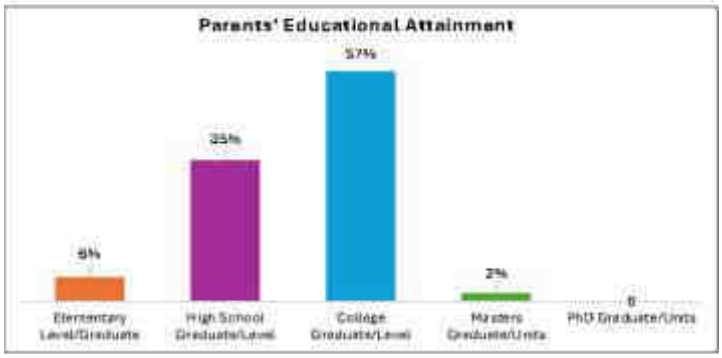
4.1.1 Parents' highest educational attainment

The findings revealed (Figure 1) that a majority of the learners' parents had attained higher levels of formal education. More than half (57%) were college graduates or levels, while 35% completed or have at least reached secondary education. A small proportion (6%) reached only the elementary level, and only 2% pursued master's degree coursework, with no respondents holding a doctoral degree or units.

The dominance of college-educated parents suggests that most learners come from households where adults likely possess the academic skills and literacy needed to support learning. Research has consistently shown that higher parental education is linked to increased academic involvement at home and more positive learning outcomes among children (Davis-Kean, 2005; Jeynes, 2016). Parents of learners with college education tend to provide enriched learning environments, communicate higher expectations, and model academic engagement, all of which are influential in strengthening students' motivation and academic performance in school.

Figure 1.

Highest Educational Attainment of the Learners' Parents



Parental education level has also been identified as a strong predictor of learner achievement because it shapes the quality of interactions, exposure to educational resources, and the degree of support provided for school tasks (Sirin, 2005). In households where parents have limited formal schooling, support for academic tasks may also be less frequent or less aligned with school expectations, potentially affecting learners' achievement and development of higher-order thinking skills. This may explain the small proportion (6%) of learners whose parents only completed elementary schooling, reflecting a minority of households potentially facing challenges in providing academically stimulating home settings.

Moreover, the observed distribution aligns with previous studies highlighting the central role of parents' educational background in shaping students' academic achievement and cognitive development (Donnelly, 2015; Cheung & Andersen, 2017). This demographic profile provides useful context for understanding the home-school influences considered in the succeeding path analysis, especially in relation to learners' critical thinking skills and biology achievement.

4.1.2 Parental support

The findings as shown in Table 1 revealed that the overall level of parental support perceived by the learners was fair ($\bar{x}$ = 3.43), indicating that parents are involved in their children's education but there remains significant room for improvement. This aligns with the view that parental involvement especially in the Philippines is often influenced by socio-economic demands, family structure, and parental availability (Bernardo, 2019). However, although parents show concern and engagement, their level of participation does not consistently reach the ideal standard of active academic involvement.

Table 1.
Level of Learners' Parental Support

Aspects of Parental Support	SD	Mean ($\bar{x}$)	Verbal Interpretation*
Attends school meeting	1.06	3.84	Good
Makes a regular follow-up at school	1.05	3.46	Fair
Provides proper medication when ill.	0.91	4.27	Good
Discusses matters regarding personal life	1.12	3.56	Fair
Pays school account or contributions on time	0.86	4.04	Good
Show concern when ask for school payment, fees, or contributions	1.19	2.61	Fair
Provides books, activity sheets, reading materials, etc.	1.09	3.59	Fair
Helps in making my assignments	1.06	2.40	Fair
Discusses matters with teachers or adviser with regards to performances in school	1.17	3.13	Fair
	Over-all Mean	3.43	Fair

**1.00-2.33 = Poor; 2.34-3.3.67 = Fair; 3.68-5.00 =Good*

Several indicators were also rated "good", particularly parental attendance in school meetings ($\bar{x}$ = 3.84), timely payment of school fees ($\bar{x}$ = 4.04), and provision of proper medication when a child is ill ($\bar{x}$ = 4.27). These results suggest that parents place importance on meeting school obligations and ensuring their children's welfare. Moreso, a study conducted in the Philippines have shown that parents commonly prioritize basic needs and school financial responsibilities as part of their role, especially in public schools (Pascual, 2021). Such forms of support indicate a strong sense of responsibility and recognition of the parents' role in the child's development.

However, most indicators related to direct academic support were evaluated as "fair", including helping with assignments ($\bar{x}$ = 2.40), discussing personal matters ($\bar{x}$ = 3.56), and engaging with teachers regarding school performance ($\bar{x}$ = 3.13). These findings mirror earlier assertions that while Filipino parents value education highly, their capacity to provide academic assistance may be limited by educational attainment, time constraints, or work commitments (Caliwan & Javate, 2020). With many Filipino parents working long hours or multiple jobs, academic involvement is often reduced, leading to less direct guidance at home (Crisostomo, 2019).

Furthermore, a notable area of concern is parental support in the provision of school fees and contributions, which received a fair rating when considering whether parents show concern when such payments are requested ($\bar{x}$ = 2.61). This may be attributed to persistent economic challenges faced by Filipino households. According to studies, many families in the Philippines struggle financially, affecting their consistency in supporting school-related expenses (Ablaza & Francisco, 2022). Such constraints can contribute to learner stress and reduced motivation, as the perception of limited parental support may negatively impact academic confidence.

Similarly, the "fair" rating on the provision of learning materials ($\bar{x}$ = 3.59) suggests that while many parents try to provide books and school supplies, adequacy may vary across households. The Department of Education (DepEd) has emphasized that access to home learning materials is a strong predictor of academic performance, especially in science subjects such as Biology (DepEd, 2020). This reinforces the importance of strengthening material support, especially for learners from economically disadvantaged backgrounds.

Taken together, the findings highlight a pattern typical in Philippine educational settings: parents demonstrate strong concern for student welfare and school compliance, yet academic guidance and communication with teachers are less frequent. This supports the argument that parental support is multidimensional, and while Filipino parents often succeed in providing emotional and financial care, academic engagement remains a critical area for improvement (Bernardo, 2019; Caliwan & Javate, 2020). Enhancing parent–teacher partnerships and providing community-based learning support systems may help bridge this gap.

4.1.3 Home educational resources

The results showed in Table 2 revealed an overall mean score of 3.43, interpreted as "fair", indicating that learners generally had moderate access to educational resources at home. Among the indicators, access to educational technology scored the highest ($\bar{x}$ = 4.06, "Good"), suggesting that most students had devices such as computers, tablets, or mobile phones available for learning. In contrast, print-based materials ($\bar{x}$ = 3.06, "Fair") and specialized learning tools such as science kits and art supplies ($\bar{x}$ = 3.13, "Fair") scored lower, indicating more limited availability.

Table 2.
Home Educational Resources as Perceived by Learners

Home Educational Resources	SD	Mean ($\bar{x}$)	Verbal Interpretation*
Quiet and dedicated learning space for studying	1.09	3.41	Fair
Enough textbooks, magazines, and other printed materials are available	1.07	3.06	Fair
Educational technology (e.g., computers, tablets, mobile phones) is accessible and readily available	0.92	4.06	Good
Fast and reliable internet connection	1.13	3.51	Fair
Science kits, art supplies, school supplies or other educational materials are available	0.97	3.13	Fair
	Over-all Mean	3.43	Fair

**1.00-2.33 = Poor; 2.34-3.3.67 = Fair; 3.68-5.00 =Good*

Access to educational technology at home is increasingly recognized as a significant predictor of learners' achievement and learning engagement. With digital tools becoming essential for research, assignments, and interactive learning, students with strong access to technology are often better positioned to keep up with academic requirements and develop digital literacy skills (OECD, 2020). Moreover, technology access enhances opportunities for online learning, multimedia resources, and independent exploration, contributing to skills development including reasoning and self-paced learning (Claro et al., 2018).

However, even though some of the home learning environment factors have been seen of relevant importance, other elements received only "fair" ratings. The mean of 3.41 for having a "quiet and dedicated learning space" suggests that while many students have a place to study, it may not always be conducive to focused academic work. A structured and distraction-free study space has been shown to positively impact concentration, study habits, and academic performance (Evans et al., 2010). Lack of such an environment may hinder students' ability to engage effectively in sustained academic tasks.

Similarly, "limited access to printed learning materials, such as textbooks and supplementary reading resources", may restrict opportunities for deep reading, reinforcement, and independent learning. Research indicates that print exposure at home contributes to vocabulary acquisition, comprehension, and overall academic achievement, particularly in literacy and content learning (Mol & Bus, 2011). The same trend is reflected in the modest ratings for educational supplies, which can constrain students' ability to conduct hands-on projects, experimentation, and creative tasks important in science learning.

The mean score of 3.51 for internet connectivity, interpreted as "fair", suggests that while many families have access, the connection may not always be reliable or fast enough to support extensive online learning. During the shift toward digital education, reliable internet access has become a strong predictor of equity in academic opportunity, especially in developing critical thinking and inquiry-based learning through online resources and collaborative platforms (Van Deursen & Van Dijk, 2019).

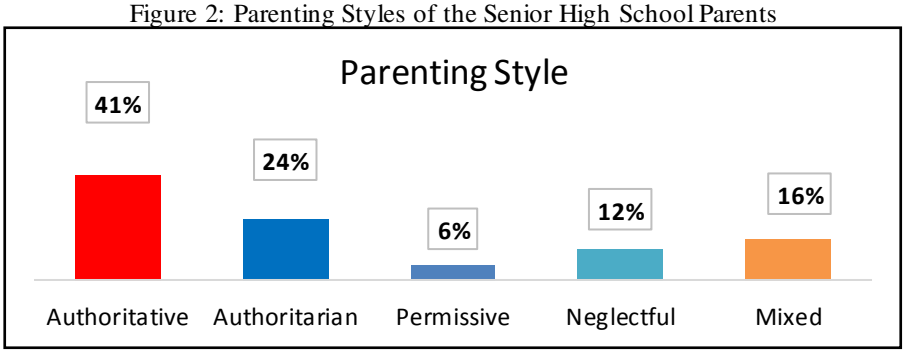
Moreover, the results also highlight that while most learners have access to essential digital devices, several foundational academic supports—such as print materials, dedicated study spaces, and specialized learning tools—remain limited. These findings underscore the importance of strengthening home resource environments to ensure that learners can fully engage in academic tasks and develop higher-order thinking skills.

4.1.4 Parenting style

As shown in Figure 2, majority of learners perceived their parents to be using an authoritative parenting style (41%), followed by authoritarian (24%), mixed (16%), neglectful (12%), and permissive (6%). The dominance of authoritative parenting reflects a generally supportive home environment characterized by warmth, responsiveness, and reasonable discipline.

Authoritative parenting is widely recognized in developmental literature as the most effective style in promoting positive academic, emotional, and social outcomes. Parents who use this approach balance clear expectations with emotional support, which enhances autonomy, motivation, and learning (Baumrind, 1991). Such parenting is associated with strong school engagement and higher academic achievement because children in these environments develop stronger self-regulation and intrinsic motivation (Steinberg, 2001).

Figure 2: Parenting Styles of the Senior High School Parents



In contrast, 24% of the learners reported experiencing authoritarian parenting, a style defined by strict rules, high expectations, and limited warmth or autonomy support. Research indicates that while this approach may promote discipline, it can also restrict independent thinking and reduce engagement in higher-order cognitive processes (Lam et al., 2012). As critical thinking in science requires reasoning, inquiry, and open exploration, learners raised in authoritarian households may experience limitations in opportunities for such cognitive growth.

A smaller proportion (6%) experienced permissive parenting, characterized by warmth but few rules or expectations. Studies suggest that permissive parenting may not provide children with the structure and guidance necessary for academic responsibility and persistence (Milevsky et al., 2007). Similarly, 12% reported neglectful parenting, which is generally associated with the poorest academic outcomes due to insufficient emotional and academic support at home (Musitu & Garcia, 2004).

The presence of mixed parenting styles (16%) also indicates that some parents employ varying practices depending on situation, stress, or context. Mixed or inconsistent parenting has been shown to create uncertainty in expectations and may affect children's academic confidence and motivation (Aunola et al., 2000).

Furthermore, the predominance of authoritative parenting aligns with literature emphasizing its positive influence on academic development, particularly in fostering critical thinking, autonomy, and consistent learning habits. These results provide important context for understanding how home factors interact with academic performance in biology and higher-order thinking skills.

4.1.5 Family interaction

The findings shown in Table 3 revealed an overall mean score of 3.64, verbally interpreted as "fair", indicating that learners generally experienced moderate levels of family interaction at home. Among the five dimensions assessed, emotional support ($\bar{x}$ = 4.00, Good) and boundaries and independence ($\bar{x}$ = 3.92, Good) scored the highest, suggesting that most families provide a supportive emotional climate while allowing learners a balanced level of autonomy.

Table. 3
Level of Family Interaction as Perceived by Learners

Aspects of Family Interaction	SD	Mean ($\bar{x}$)	Verbal Interpretation*
Communication	1.05	3.54	Fair
Emotional Support	1.10	4.00	Good
Conflict Resolution	1.06	3.34	Fair
Quality Time	1.06	3.47	Fair
Boundaries and Independence	1.00	3.92	Good
Over-all Mean		3.64	Fair

**1.00-2.33 = Poor; 2.34-3.3.67 = Fair; 3.68-5.00 =Good*

Emotional support is a critical aspect of family functioning, as it fosters psychological security, motivation, and positive academic outcomes. Families that express warmth, empathy, and reassurance contribute to higher levels of engagement and cognitive development among learners (Durlak et al., 2011). Likewise, providing appropriate autonomy and boundaries has been linked to improved decision-making, self-regulation, and academic competence (Smetana, 2017). These results indicate that many students benefit from an environment where independence is nurtured in developmentally appropriate ways.

In contrast, communication ($\bar{x}$ = 3.54, Fair), quality time ($\bar{x}$ = 3.47, Fair), and conflict resolution ($\bar{x}$ = 3.34, Fair) scored lower. These findings suggest that while families demonstrate emotional support and allow independence, they may lack consistently effective communication and shared time essential for strengthening relationships. Prior research highlights that productive family communication enhances mutual understanding and encourages learners to express concerns and seek help regarding school matters (Givertz & Segrin, 2014). Similarly, frequent shared time enables positive interactions that reinforce family cohesion, routines, and academic guidance (Crouter & Head, 2002).

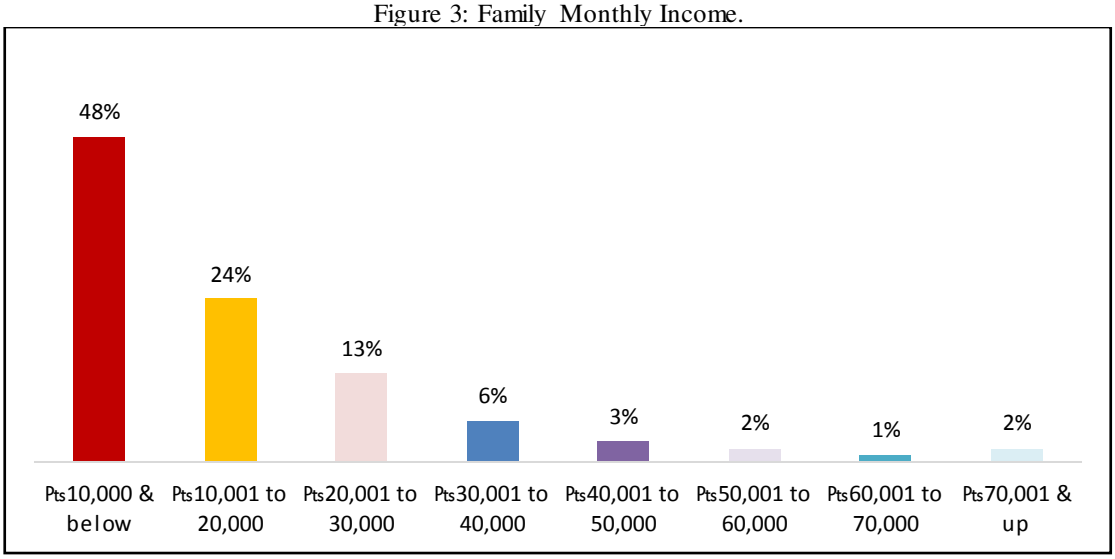
The lowest scoring element, conflict resolution, indicates that many households may struggle to address disagreements constructively. Ineffective or unresolved conflict within families has been associated with elevated stress and diminished academic and motivational outcomes among adolescents (Davies & Woitach, 2017). When disagreements are approached with openness and problem-solving strategies, however, they can contribute to the development of critical thinking, communication skills, and emotional maturity.

Taken together, the results suggest that while families generally offer supportive emotional environments and respect adolescent independence, improvements in communication quality, shared time, and conflict management may strengthen the home context further. These findings align with literature suggesting that holistic family functioning—characterized by emotional support, communication, structure, and positive interaction—plays a vital role in promoting student learning, well-being, and academic achievement.

4.1.6 Family income

Data in Figure 3 revealed that nearly half of the learners (48%) belonged to households earning ₱10,000 and below per month, indicating that a large portion of the sample came from low-income families. Additionally, 24% reported a monthly income of ₱10,001 to ₱20,000, while only a small percentage earned ₱70,001 and above (2%). These results suggest that the majority of learners were from households with limited financial resources, which may influence their educational opportunities, study conditions, and access to learning materials. In the Philippine context, poverty remains a significant barrier to academic achievement. For instance, a study by the Philippine Institute for Development Studies from PIDS (Philippine Institute Development Studies) found that many children from impoverished households drop out of school or are unable to complete their basic education due to economic pressures, such as needing to contribute to family income (PIDS, 2011).

Figure 3: Family Monthly Income.



Socioeconomic status (SES), particularly family income, has long been recognized as a significant predictor of academic achievement and learning outcomes. Students from low-income households often face economic constraints that limit access to educational resources such as books, technology, private tutoring, and enriched academic environments (Duncan & Murnane, 2014). Families with limited financial means may also encounter stressors that reduce the time and capacity parents have to support their children's schooling (Conger et al., 2010). These conditions can indirectly affect students' academic motivation, concentration, and overall school engagement. Additionally, research on socio-economic status in Philippine schools has demonstrated that lower family income is positively correlated with poorer academic performance (Guevarra, Pangilinan, & Dimaunahan, 2016). Therefore, the pronounced prevalence of low-income households in this sample may partially explain limitations in students' learning engagement, resource access, and overall academic achievement.

In contrast, higher-income households typically have greater access to learning-enhancing resources and structured environments that support academic development. Prior studies have shown that children from higher SES backgrounds generally perform better

in standardized assessments and exhibit stronger cognitive development because they experience more enriched learning environments both at home and in school (Sirin, 2005). This may explain the small percentage of families in the higher-income brackets in the present study, reflecting a smaller proportion of learners with such advantages.

Economic limitations can also shape home learning conditions, including parental ability to provide educational materials, study spaces, and extracurricular learning experiences. Research indicates that financial hardship may lead to reduced parental involvement and heightened household stress, which can negatively influence students' academic and emotional functioning (Bradley & Corwyn, 2002). This is especially relevant in subjects like science, where resource availability and parental support contribute to experimentation, exploration, and analytical thinking.

Overall, the findings highlight the socioeconomic context within which learners' educational experiences take place. The predominance of low-income families suggests that many students may be navigating academic development under constrained financial conditions. This context is essential in understanding how home factors may influence learners' critical thinking skills and biology achievement in the subsequent analysis.

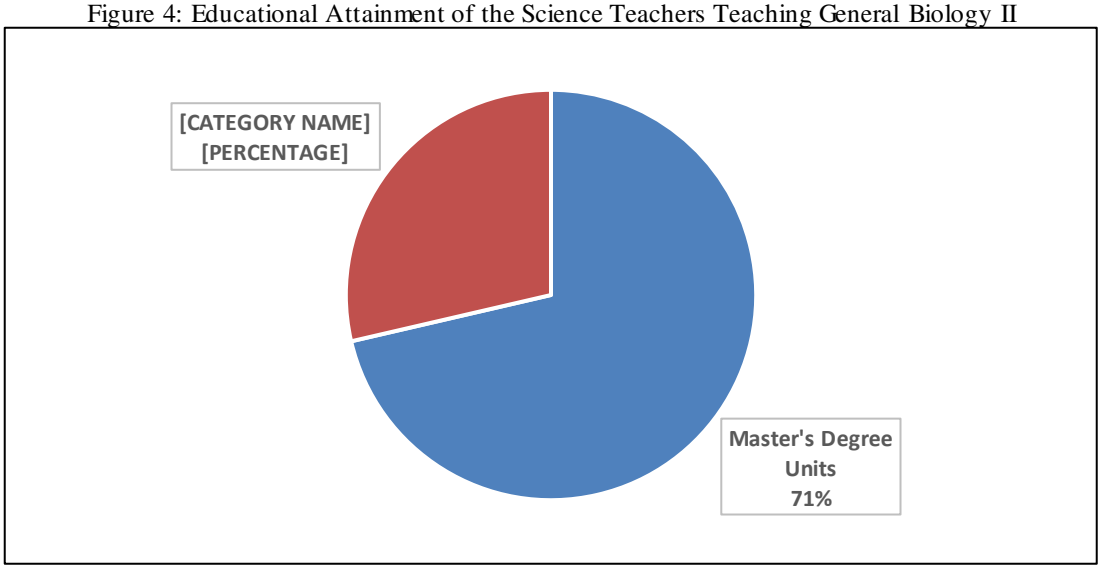
4.2 Level of learners' school influences

4.2.1 Teachers' educational attainment

The results (Figure 4) showed that a majority of teachers had advanced academic preparation, with 71% holding master's degree units and 29% having completed a full master's degree. This indicates that all teachers in the study possess some level of graduate education, reflecting a highly qualified teaching workforce.

Advanced educational attainment among teachers has been linked to improved instructional competencies, stronger content knowledge, and more effective pedagogical practices. Teachers with graduate-level training are more likely to demonstrate deeper mastery of subject matter and employ evidence-based teaching strategies that support student achievement (Darling-Hammond, 2017). In science education, such advanced preparation is especially important because it enhances teachers' capacity to engage learners in inquiry-based learning, critical thinking, and application of scientific concepts in real-world contexts (Luft & Hewson, 2014).

Figure 4: Educational Attainment of the Science Teachers Teaching General Biology II



Research further suggests that teachers with higher qualifications contribute to improved student outcomes through stronger planning, differentiated instruction, and capacity to utilize assessment data to guide learning (Stronge, 2018). This is relevant to the present study, as the professional qualifications of teachers may influence learners' biology achievement and development of higher-order thinking skills. Highly educated teachers are more likely to create cognitively rich learning environments that foster analytical reasoning, scientific inquiry, and meaningful academic engagement.

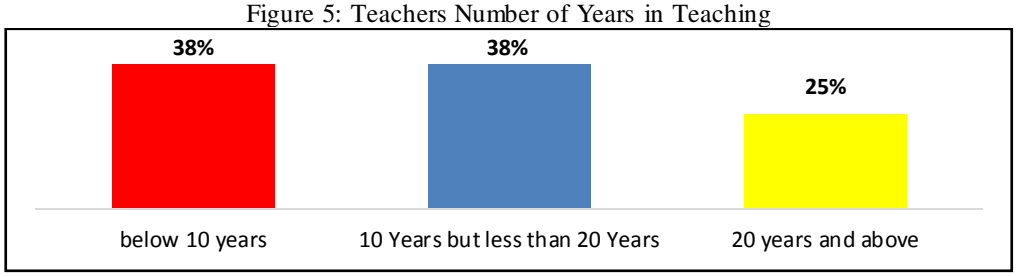
Moreover, the presence of a faculty where all members have pursued or completed graduate studies aligns with policy initiatives encouraging continuous professional development among educators. Advanced teacher qualifications reflect a commitment to lifelong learning and professional excellence, which are critical in sustaining educational quality and advancing student performance (Avalos, 2011).

Furthermore, the findings suggest that learners in this study were taught by a well-prepared instructional force, which may positively shape classroom instruction and student learning outcomes. This level of teacher qualification provides a strong foundation for understanding how educational inputs influence learners' critical thinking skills and academic achievement in the subsequent analyses.

4.2.2 Teachers' number of years in Teaching

The results in Figure 5 showed that 38% of teachers had less than 10 years of teaching experience, another 38% had 10 to 19 years, and 25% had 20 years or more. This distribution indicates a balanced teaching force composed of both early-career and highly experienced educators, creating a diverse instructional environment where newer teachers and seasoned practitioners coexist.

Figure 5: Teachers Number of Years in Teaching



Teaching experience has long been recognized as an important factor influencing instructional effectiveness and student learning. Early-career teachers, while still developing classroom management and instructional strategies, often bring current pedagogical approaches and innovative methods aligned with contemporary educational practices (Ingersoll & Strong, 2011). Their presence in the sample suggests that a significant portion of learners may be exposed to updated teaching methods, technology integration, and newer curriculum perspectives.

On the other hand, teachers with 10 to 20 years of experience—who also represent 38% of the group—are often at a stage where professional expertise, confidence, and instructional skill have significantly developed. Research shows that teaching effectiveness generally increases during the first decade of professional practice as teachers refine management skills, content knowledge, and the ability to adapt instruction to student needs (Kini & Podolsky, 2016).

Meanwhile, the 25% of teachers with more than 20 years of experience likely contribute deep professional wisdom, classroom mastery, and strong familiarity with curriculum demands. Veteran teachers play a valuable role in promoting school stability, mentoring younger colleagues, and ensuring continuity of instructional quality. Studies indicate that experienced teachers tend to demonstrate stronger instructional decision-making and are often more effective in supporting diverse learners through established pedagogical strategies (Rice, 2010).

The mixed distribution of experience levels is beneficial for student learning, as schools that support a healthy blend of novice and experienced teachers often demonstrate stronger instructional capacity and collaborative improvement (Papay & Kraft, 2020). In the context of the present study, this balance suggests that learners have varied exposure to instructional styles, potentially influencing their biology achievement and development of critical thinking skills in different ways.

4.2.3 School resources

The overall mean score for school resources as shown in Table 4 was 3.61, interpreted as "fair", indicating that while schools possess several essential facilities and tools, resource availability and quality remain uneven across different areas. Among the indicators, the highest rating was recorded for the availability of adequate classrooms ($\bar{x}$ = 4.19, Good), suggesting that most schools can comfortably accommodate their student populations. Adequate classroom space is essential for maintaining effective class sizes, allowing teachers to manage learning more efficiently and ensuring that instructional activities can proceed without overcrowding (OECD, 2020).

Access to computers and digital tools for both students and teachers ($\bar{x}$ = 3.89, Good) and well-equipped laboratories ($\bar{x}$ = 3.75, Good) reflects the schools' efforts to support technology integration and hands-on learning. Well-resourced laboratories enhance experiential learning, problem-solving, and the development of scientific reasoning (Hofstein & Kind, 2012). Similarly, the presence of computers in schools supports students' digital literacy development and teachers' access to modern instructional strategies and content (Claro et al., 2018).

Table 4.
Senior High School Learners' Aspects of School Resources

Aspects of School Resources	SD	Mean ($\bar{x}$)	Verbal Interpretation*
Adequate classrooms for all students	0.79	4.19	Good
Laboratories are well-equipped with tools and materials	1.00	3.75	Good
Library offers a sufficient collection of books, journals, and digital resources	0.99	3.19	Fair
Sports facilities and equipment are available and well-maintained	0.95	3.36	Fair
Computers and other digital tools are accessible for both students and teacher	0.91	3.89	Good
Internet connectivity is reliable and supports educational activities	1.09	3.39	Fair
Access to educational software and online learning platforms.	0.97	3.58	Fair
Multimedia equipment (e.g., projectors, smart boards) is available	1.03	3.57	Fair
Over-all Mean		3.61	Fair

**1.00-2.33 = Poor; 2.34-3.3.67 = Fair; 3.68-5.00 =Good*

However, several aspects scored only fair, suggesting areas needing improvement. For example, the school library resources were rated moderately ($\bar{x}$ = 3.19, Fair), indicating limited collections of books, journals, and digital materials. Research shows that strong library collections contribute significantly to reading achievement, academic success, and student engagement in learning (Lance & Kachel, 2018). This limited resource availability may hinder students' ability to independently expand knowledge beyond classroom instruction.

Similarly, sports facilities ($\bar{x}$ = 3.36, Fair) and multimedia equipment ($\bar{x}$ = 3.57, Fair) were moderately available. Adequate sports and recreation facilities support physical development, teamwork, and overall student well-being (Bailey, 2006), while multimedia tools are increasingly fundamental in modern teaching for enhancing engagement, visualization, and differentiated instruction.

Meanwhile, internet connectivity ($\bar{x}$ = 3.39, Fair) and access to educational software and online learning platforms ($\bar{x}$ = 3.58, Fair) scored moderately, pointing to ongoing challenges in sustaining technology-supported learning. Reliable internet access has become a critical factor in ensuring equitable learning opportunities, especially in digital-based education (Van Deursen & Van Dijk, 2019). Limited connectivity may restrict the use of digital instructional platforms and online learning resources, affecting both teaching and student performance.

In summary, while the results show that schools have strong foundational infrastructure, including classrooms, laboratories, and computers, several areas—such as libraries, sports facilities, multimedia equipment, and internet-based access—require further development. Addressing these gaps is vital to ensuring that schools provide an enriched learning environment that fully supports 21st-century learning competencies.

4.2.4 Peer interaction

The findings shown in Table 5 indicate that overall peer interaction among learners was rated "good" ($\bar{x}$ = 3.82), suggesting that students generally experience positive social dynamics within their school environment. High-quality peer relationships play a crucial role in shaping students' emotional, academic, and social development, influencing their motivation, learning engagement, and well-being (Wentzel, 2017).

Among the indicators, peer relationships received the highest mean score ($\bar{x}$ = 3.96, Good), indicating strong interpersonal bonds among learners. Supportive peer relationships have been shown to improve academic outcomes, increase persistence in learning tasks, and foster a sense of belonging in the school community (Juvonen & Espinoza, 2015). Such positive relationships help learners feel socially connected, reducing feelings of isolation and improving engagement in school activities.

Table 5.
Peer Interaction among Senior High School Learners

Aspects of Peer Interaction	SD	Mean ($\bar{x}$)	Verbal Interpretation*
Peer Support	0.88	3.87	Good
Social Inclusion	0.91	3.81	Good
Peer Relationships	0.99	3.96	Good
Conflict and Resolution	0.90	3.64	Fair
Peer Influence	0.88	3.83	Good
	Over-all Mean	3.82	Good

**1.00-2.33 = Poor; 2.34-3.3.67 = Fair; 3.68-5.00 =Good*

Similarly, learners rated peer support ($\bar{x}$ = 3.87, Good) and peer influence ($\bar{x}$ = 3.83, Good) positively. Peer support is recognized as one of the strongest predictors of students' academic success and emotional resilience (Wentzel & Muenks, 2016). When learners receive encouragement and assistance from classmates, they become more motivated to collaborate, persist through challenges, and participate actively in learning. Meanwhile, positive peer influence can reinforce school-friendly norms and behaviors, helping shape responsible attitudes toward study habits and classroom participation (Ryan, 2001).

Social inclusion ($\bar{x}$ = 3.81, Good) was also perceived positively, suggesting that most students feel socially accepted within their peer groups. Inclusive peer environments contribute to students' sense of identity, emotional security, and overall school satisfaction, which in turn enhances academic engagement and socio-emotional development (Booth & Ainscow, 2016).

The only dimension rated as "fair" was conflict and resolution ($\bar{x}$ = 3.64), indicating that while conflicts exist—which is natural in adolescent peer groups—the strategies used to resolve them may not always be effective. Conflict management skills, such as communication, negotiation, and emotional regulation, are critical for maintaining healthy peer interactions (Johansson, 2019). Limited conflict resolution competence may hinder students' ability to sustain positive relationships and may affect classroom climate if not effectively supported by teachers and school programs.

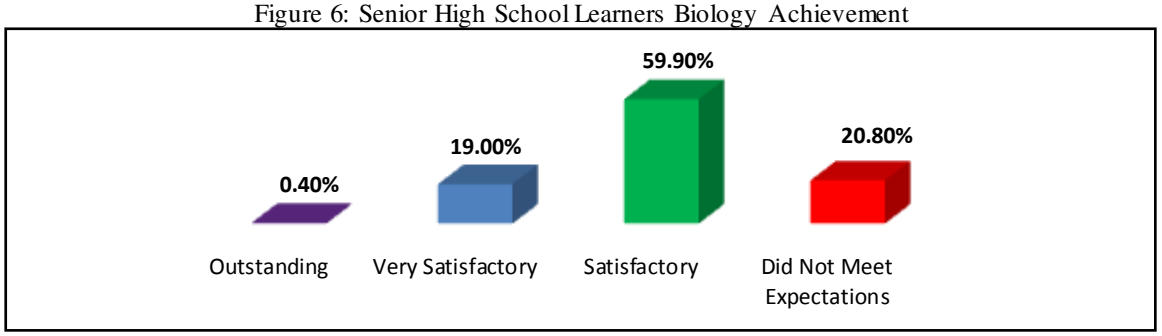
Moreover, the results suggest that learners benefit from generally supportive, inclusive, and positive peer environments, although there remains a need to strengthen students' conflict resolution skills. Schools may consider implementing programs focused on peer mediation, social-emotional learning, and collaborative problem-solving to help improve these areas and further enhance peer interaction outcomes.

4.3 Level of Biology achievement among Grade 12 senior high school learners

The findings as shown in Figure 6, reveal that the overall academic performance of learners in Biology is concentrated within the mid-performance range. A majority of students obtained ratings classified as Satisfactory (59.90%), followed by Very Satisfactory (19.00%), while only 0.40% attained Outstanding performance. Conversely, 20.80% of learners did not meet expectations, indicating that a substantial portion of students require additional instructional and academic support. This performance pattern suggests that while most learners demonstrate basic competency in Biology, relatively few reaches advanced levels of mastery.

Academic achievement in science subjects, including Biology, is understood to be influenced by a complex interaction of instructional practices, learner characteristics, and environmental support systems (Glynn & Muth, 2017). In the Philippine context, research similarly highlights that student performance in science is often shaped by the availability of school resources, quality of instruction, and the learning environment at home and in school (Bernardo, 2019; Cabansag, 2020). These factors may contribute to the currently modest level of high achievement and the notable proportion of low-performing learners.

Figure 6: Senior High School Learners Biology Achievement



The low percentage of "Outstanding" performance (0.40%) may reflect limited opportunities for advanced engagement, higher-order thinking, and inquiry-based learning experiences which are critical for deeper scientific understanding. Studies in the Philippines have shown that inquiry-driven and laboratory-based instruction positively influence student engagement, conceptual mastery, and performance in science (Antolin & Buenviaje, 2022; Penetrante, 2017). The limited number of top-performing learners may therefore signal the need to further enrich instructional approaches that promote critical thinking, application of scientific concepts, and authentic learning tasks.

On the other hand, the 20.80% of learners who did not meet expectations point to challenges that may include difficulties in foundational knowledge, access to learning materials, or gaps in instructional support. Local studies report that underachievement in science is frequently associated with inadequate home learning environments, limited exposure to functional laboratories, and low self-efficacy in scientific learning (Bolok, 2019; Caballes & Almario, 2021). Such findings underscore the need for targeted interventions, including remediation programs, structured academic support, and differentiated instructional strategies.

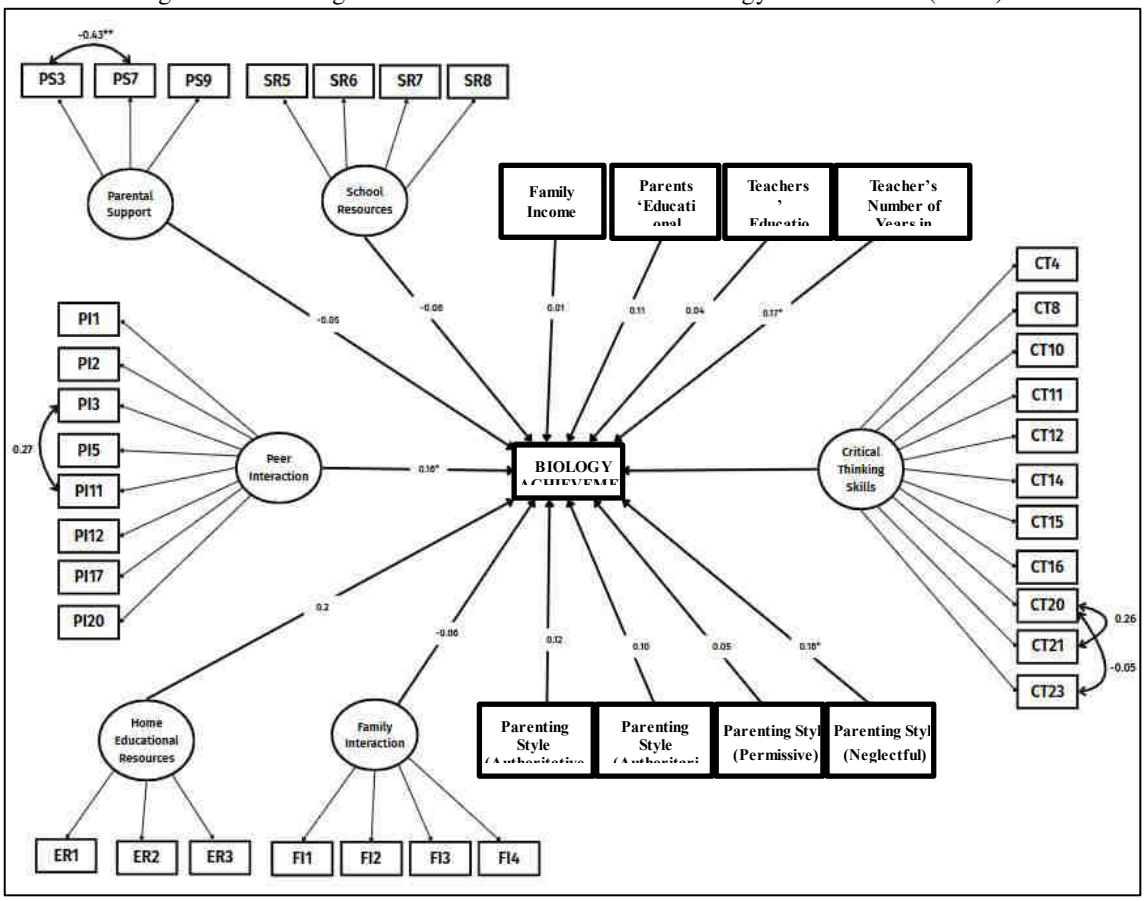
Finally, the results suggest that while most learners meet minimum academic expectations in Biology, there is significant room for improvement in both raising the proportion of high-achieving students and reducing the number of those who fall below standards. As Schunk and DiBenedetto (2020) emphasize, achievement in science is strongly linked to coordinated support from the home, school, and social environment. Therefore, improving instructional quality, expanding access to learning resources, and strengthening learner support systems may contribute to enhanced performance in Biology and better preparation for higher-level scientific learning.

4.4. Structural model showing pathways of the home-school influences on learners' Biology achievement

The structural equation model predicting Biology Achievement as illustrated in Figure 7, demonstrated an acceptable overall fit to the data, $\chi^2(768) = 1190.82$, $p < .001$, with RMSEA = .045 (90% CI [.040, .050]) and a non-rejected test of close fit ($p = .948$). Although the CFI (.859) and TLI (.848) were marginally below the recommended .90 threshold, the SRMR value of .071 was within acceptable limits (< .08), indicating that the model provides a reasonable representation of the observed data. The predictors explained 11% of the variance in biology scores ($R^2 = .110$), which is moderate but consistent with the multifactorial nature of academic achievement (Bernardo, 2020).

The measurement model yielded adequate factor loadings, supporting the validity of the latent constructs representing parental and school influences. However, the structural paths revealed that many expected predictors did not exert significant direct effects on biology performance. Variables such as Parental Support ($\beta = -.053$, $p = .717$), Home Educational Resources ($\beta = .136$, $p = .353$), and Family Interaction ($\beta = .125$, $p = .391$) failed to predict biology scores directly. This trend reflects previous findings in the Philippines, where parental involvement and home support do not always translate into measurable improvements in academic achievement, especially in science subjects (Manalo, Yumang, & Almazan, 2023). Studies suggest that while Filipino parents commonly provide emotional or logistical learning support, such involvement may not directly cultivate advanced content learning or scientific reasoning needed for performance in Biology (Caliwan, 2019).

Figure 7: Path Diagram of the Structural Model on Biology Achievement (Score)



On the school side, two variables emerged as significant direct predictors. Peer Interaction showed a positive effect on performance (β = .156, p = .036), suggesting that collaborative exchanges among learners contribute meaningfully to understanding scientific concepts. This aligns with Philippine research demonstrating that peer-assisted and group learning enhances conceptual retention, engagement, and problem-solving in science classrooms (Austria & Valdez, 2018; Orbea & Bautista, 2020). In senior high school settings, students who frequently engage in shared explanations, discussions, and inquiry-based group tasks reportedly demonstrate stronger mastery of biological concepts (Lajom & Magno, 2019).

Similarly, Teachers' Years of Experience (TYT) was a significant predictor (β = .171, p = .011), indicating that students taught by more experienced teachers tend to achieve higher biology scores. Philippine studies offer similar evidence: experienced teachers often possess stronger content knowledge, classroom management skills, and instructional strategies, which positively shape student performance in science (Ramirez & Bautista, 2020). Moreover, the Department of Education has emphasized that teaching experience strengthens teacher adaptability and pedagogical decision-making, both of which are essential for supporting inquiry-based learning and scientific reasoning (DepEd, 2021).

A surprising finding was the significant direct positive effect of the Neglectful Parenting Style (PST4) on biology achievement (β = .156, p = .039). While counterintuitive, similar patterns have occasionally appeared in studies where less parental oversight leads to greater autonomy and self-regulation in learning. In some Philippine contexts, adolescents who receive minimal academic monitoring may develop independent study habits or seek academic support from peers and teachers instead (Villanueva, 2020). However, this result should be interpreted with caution, as neglectful parenting is more typically associated with lower achievement and weaker motivation (Castro, 2019). The finding may suggest indirect compensatory mechanisms—for example, students with minimal home supervision relying more on peer networks, school structures, or personal agency to succeed.

Other parenting styles—Authoritative, Authoritarian, and Permissive—did not significantly predict biology scores, supporting the claim that parenting style alone may not be a strong determinant of academic performance in senior high school once school factors are considered. Local studies have shown that the impact of parenting style becomes more indirect during late adolescence, as peer engagement and school influences increasingly shape learning outcomes (Gurdiel & Sandoval, 2022).

Overall, the model reinforces the idea that in this context, school-based and peer-driven factors are more influential in shaping biology performance than home conditions or parental behavior alone. As learners progress into higher secondary levels, they may rely more on teacher expertise, classroom structures, and collaborative learning opportunities to succeed in highly conceptual subjects like Biology.

Table 6 showing the analysis of the structural model revealed varying levels of influence of home and school factors on students' Biology Achievement. While several predictors were included, only four variables exhibited significant direct effects: Peer Interaction, Parental Education, Teachers' Years of Experience, and Neglectful Parenting Style. These findings highlight the

complex interplay of learning environments influencing senior high school academic outcomes, particularly in a content-heavy subject like Biology.

Table 6.

Standardized Direct Effects on Biology Achievement (Score)

Predictor → Biology Achievement (Score)	β (Standardized)	p-value	Significance
Parental Support (PS)	−0.053	0.717	Not Significant
Home Educational Resources (ER)	0.136	0.353	Not Significant
Family Interaction (FI)	−0.062	0.671	Not Significant
School Resources (SR)	−0.060	0.410	Not Significant
Peer Interaction (PI)	0.156	0.036	Significant
Parental Education (PEA)	0.114	0.045	Significant
Teachers' Educational Attainment (TEA)	0.042	0.535	Not Significant
Teachers' Years of Experience (TYT)	0.171	0.011	Significant
Family Income (FI)	0.007	0.910	Not Significant
PST1 (Authoritative)	0.119	0.144	Not Significant
PST2 (Authoritarian)	0.098	0.208	Not Significant
PST3 (Permissive)	0.054	0.473	Not Significant
PST4 (Neglectful)	0.156	0.039	Significant

On home factors or influences, Parental Support, Parental Education, Home Educational Resources, Family Interaction, Family Income, and most Parenting Style categories did not demonstrate significant direct effects on Biology Achievement. For example, Parental Support (β = –.053, p = .717) and Home Educational Resources (β = .136, p = .353) were not significant predictors. This result aligns with studies showing that while Filipino parents often express strong emotional encouragement and value education, such forms of involvement may not directly translate into improved performance in specialized subjects like Biology (Manalo, Yumang, & Almazan, 2023; Caliwan, 2019).

Similarly, Family Interaction (β = –.062, p = .671) also showed no significant contribution. Previous Philippine studies suggest that positive family relationships support general academic well-being but do not necessarily influence subject-specific performance unless parents possess the technical ability to assist with course content (Delos Santos & Manigo, 2021).

Family Income (β = .007, p = .910) also yielded no significant direct effects. This supports findings that socioeconomic and educational background indicators in the Philippines may influence access to learning opportunities but do not always guarantee higher academic achievement, particularly when school-level instruction and experiences carry greater weight (Ramirez & Bautista, 2020).

Interestingly, among the parenting style variables, only Neglectful Parenting Style (PST4) showed a significant effect (β = .156, p = .039). While counterintuitive, this pattern appears occasionally in studies where decreased parental intervention encourages students to develop greater self-reliance, independence, or reliance on peer networks for academic support (Villanueva, 2020). Nevertheless, the finding must be interpreted cautiously, as neglectful parenting is more commonly associated with poorer motivation and weaker academic outcomes (Castro, 2019).

On school factors, School Resources (β = –.060, p = .410) showed no significant direct effect. Although adequate facilities and materials are essential for science education, Philippine evidence suggests that resource availability alone is insufficient to improve performance without consistent pedagogical integration and effective teacher facilitation (Austria & Valdez, 2018). This may explain why learning outcomes are more strongly driven by instructional and interpersonal factors in the classroom.

A key significant finding was the strong positive effect of Peer Interaction (β = .156, p = .036). This suggests that students who engage more actively with their classmates—through group discussions, sharing of ideas, or collaborative tasks—tend to achieve higher Biology scores. Philippine research highlights similar outcomes, demonstrating that peer-assisted learning enhances conceptual understanding, cognitive engagement, and knowledge retention in science subjects (Orbea & Bautista, 2020; Lajom & Magno, 2019). For senior high school students, collaborative work fosters increased mastery of complex biological processes and terminology through social learning exchanges.

Another significant predictor was Teachers' Years of Experience (β = .171, p = .011). This aligns strongly with Philippine studies emphasizing that experienced teachers possess not only stronger instructional skills but also a deeper understanding of student diversity and learning needs (Ramirez & Bautista, 2020). In science education, experienced teachers are better able to scaffold inquiry-based learning, address student misconceptions, and provide richer learning contexts that support achievement (Austria &

Valdez, 2018). The result reinforces Department of Education guidance that sustained classroom experience enhances teaching competency and improves student outcomes (DepEd, 2021).

Teachers' Education (β = .042, p = .535), however, did not significantly predict achievement. This suggests that formal qualifications alone may not demonstrate measurable effects unless paired with practical classroom experience, a trend also observed in previous local studies (Gurdiel & Sandoval, 2022).

Finally, the findings indicate that school-based social and instructional factors exert greater influence on Biology performance than home-related factors. Peer engagement and teacher experience emerged as the most meaningful direct contributors, while most home variables showed no direct impact. These results suggest that by senior high school, learners' academic success in Biology may depend more on learning environments and relationships formed inside the school rather than parental involvement or household conditions.

5. Conclusion and Recommendations

5.1 Conclusion

This study concludes that learners' Biology achievement at the senior high school level is shaped by a complex interaction of home and school influences, with school-based and peer-related factors exerting stronger direct effects than most home-related variables. While learners generally experienced moderate to favorable home environments, these conditions alone were insufficient to directly predict academic performance in Biology.

In terms of home influences, parents' educational attainment emerged as a significant, though modest, predictor of Biology achievement, suggesting that parental academic background may indirectly shape learners' study orientation and learning dispositions. However, other home variables—including parental support, home educational resources, family interaction, family income, and most parenting styles—did not demonstrate significant direct effects on Biology performance. This indicates that by senior high school, learners' academic outcomes in a cognitively demanding subject such as Biology are less dependent on direct parental involvement and more influenced by school-based learning contexts.

The finding that neglectful parenting style showed a significant positive effect on Biology achievement should be interpreted with caution. Rather than indicating a beneficial effect of parental disengagement, this result may reflect increased learner autonomy and self-reliance during late adolescence, where students compensate for limited home supervision by drawing more heavily on peer networks, teacher support, and independent learning strategies.

With respect to school influences, the study concludes that peer interaction and teachers' years of experience are the most influential direct predictors of Biology achievement. Positive peer interaction enhances collaborative learning, conceptual understanding, and engagement in Biology, while experienced teachers contribute to higher achievement through refined instructional strategies, classroom management skills, and effective scaffolding of scientific concepts. In contrast, teachers' educational attainment and school resources did not directly predict achievement, suggesting that formal qualifications and resource availability alone are insufficient without effective classroom implementation and instructional expertise.

Overall, the Biology achievement of most learners remained at the satisfactory level, with very few reaching outstanding performance and a substantial proportion failing to meet expectations. This performance pattern suggests limited opportunities for higher-order thinking, inquiry-based learning, and advanced engagement in Biology instruction. The modest proportion of explained variance in the structural model further reinforces the conclusion that Biology achievement is multifactorial and influenced by dynamic interactions among learners, teachers, peers, and learning environments.

In summary, this study concludes that improving senior high school learners' Biology achievement requires a stronger focus on enhancing classroom interactions, peer-supported learning, and teacher effectiveness, rather than relying primarily on home-based interventions. As learners advance in secondary education, the school environment increasingly becomes the primary context through which academic success in Biology is cultivated.

5.2 Recommendations

Based on the findings of this study, the following recommendations are proposed:

Strengthen Peer-Based Learning Strategies- Schools should intentionally integrate cooperative learning, peer tutoring, and collaborative inquiry-based activities in Biology instruction. Structured group work and peer-assisted learning can be leveraged to enhance conceptual understanding, critical thinking, and engagement.

Support and Retain Experienced Teachers - Given the significant role of teaching experience, school administrators should prioritize teacher retention, mentoring programs, and professional learning communities where experienced teachers can support early-career educators, particularly in science instruction.

Enhance Instructional Use of School Resources - While schools possess basic infrastructure, greater emphasis should be placed on pedagogical integration of laboratories, digital tools, and multimedia resources. Training teachers to maximize these resources for inquiry-based and higher-order learning is essential.

Target Learners Below Expectations with Academic Interventions - Schools should implement remediation, enrichment, and differentiated instruction programs for learners who fail to meet Biology performance standards, focusing on foundational concepts and scientific reasoning skills.

Reframe Parental Involvement Programs - Parent engagement initiatives should move beyond compliance and financial support toward equipping parents—regardless of educational background—with strategies to encourage learner autonomy, study habits, and motivation rather than direct content instruction.

Develop Learner Autonomy and Self-Regulated Learning - Given the unexpected role of neglectful parenting style, schools may consider explicitly teaching self-regulation, independent learning strategies, and academic responsibility to help students manage learning demands more effectively.

Future Research Directions - Further studies may explore indirect and mediating effects of home variables, longitudinal changes across grade levels, and the role of instructional practices and assessment methods in linking critical thinking to Biology achievement.

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