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Beyond Benchmarking: A Diagnostic Inquiry into the Underlying Determinants of Low Performance in Philippine PISA Science

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ABSTRACT

The Philippines' consistently low performance in the Program for International Student Assessment (PISA) Science Assessment has sparked concerns about the country's educational quality and competitiveness. The science scores are due to socioeconomic status, teacher quality, resource deficiencies, and systemic issues. A multi-pronged approach with evidence-based interventions is recommended to improve scientific literacy. This paper conducts a diagnostic inquiry into the underlying determinants contributing to Filipino students' underachievement in PISA science. Drawing from an extensive literature review, the analysis identifies several interrelated factors spanning multiple levels of the educational system. Socioeconomic status, motivation, self-efficacy beliefs, and language proficiency emerged as significant predictors at the student level. School-level determinants include resource deficiencies, lack of qualified science teachers, and inadequate instructional practices. Furthermore, systemic issues like fragmented policy implementation, curriculum misalignment, and insufficient investment in education undermine performance. The paper argues for a holistic, multi-pronged approach targeting these diverse determinants through evidence-based interventions and policy reforms to enhance scientific literacy and elevate educational outcomes in the Philippines.

INTRODUCTION

The Programme for International Student Assessment (PISA), a widely recognized international assessment coordinated by the Organization for Economic Co-operation and Development (OECD), has become a prominent benchmark for evaluating the educational performance of nations worldwide. Despite significant efforts, only 22% of Filipino students reach the minimum proficiency level in PISA science, compared to 78% in OECD countries (OECD, 2019a). This stark contrast highlights the urgent need for targeted educational reforms. Among the core domains assessed by PISA is scientific literacy, which encompasses students' ability to engage with science-related issues, explain phenomena scientifically, and apply scientific knowledge and methodology to real-world contexts (OECD, 2019a). The Philippines' consistent underperformance in the PISA science assessment has raised concerns about the nation's ability to cultivate a scientifically literate and globally competitive workforce essential for driving innovation, economic growth, and sustainable development (Albert *et al.*, 2019). A range of factors contribute to low performance in the PISA science test in the Philippines. Alinsunurin (2021) highlights the role of learning mindsets, socioeconomic background, and reading difficulties, emphasizing the need for a learner-centered evaluation mechanism. Serder (2016) challenges the notion of low performance, suggesting that it is a constructed category influenced by various factors. Muelle (2016) underscores the impact of socioeconomic background and school composition on academic performance, while Rutkowski (2019) raises concerns about the fitness of PISA for low-performing systems.

Despite efforts by the Philippine government and educational institutions to improve educational outcomes, the root causes of this underperformance in PISA science still need to be explored. Much of the current discourse has focused on benchmarking the Philippines' performance against regional and global averages, often overlooking the nuanced and contextualized factors that shape scientific literacy among Filipino students (Genove, 2018).

To address the gap in low PISA science performance in the Philippines, this paper aims to conduct a diagnostic inquiry into its underlying determinants beyond the benchmarking approach currently dominating the discourse. These studies collectively suggest that a holistic approach, considering individual and systemic factors, is needed to address low performance in the PISA science test in the Philippines. The triennial survey conducted by the Organization for Economic Co-operation and Development (OECD) has emerged as a globally recognized benchmark for evaluating educational systems and student performance. The PISA science assessment holds particular significance among the core domains assessed, as it reflects a nation's capacity to cultivate scientific literacy, a crucial competency for navigating an increasingly knowledge-based and technology-driven world.

This analysis critically reviews literature and empirical studies to explore the complex factors shaping scientific literacy among Filipino students, including socioeconomic, educational, pedagogical, and cultural influences. Furthermore, it investigates the contextual

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factors specific to the Philippine educational landscape that may contribute to the observed performance gaps. This paper aims to foster evidence-based policymaking and promote a comprehensive and contextualized understanding of the factors that impact scientific literacy in the Philippines.

LITERATURE REVIEW

The quest to understand and address the determinants of scientific literacy and performance in international assessments has garnered significant attention from researchers, policymakers, and educators worldwide. A substantial body of literature has explored the multifaceted factors influencing student achievement in science, providing valuable insights and theoretical frameworks.

Filipino Students' Scientific Literacy in PISA

In 2018, the Philippines joined PISA examinations for the first time, involving students' responses in reading, mathematics, science, and global competencies. The PISA 2018 Framework generally characterizes scientific literacy for the purpose of this study as "the capability to interact with subject matters about sciences and think like a reflective citizen" (OECD, 2019a, 2019b). According to the PISA Science Framework, scientific literacy is usually based on various combinations of knowledge and competencies in different contexts. Student performance was reported using seven levels of proficiency. Level 6 represented those who had attained the highest level of competence while Level 2 indicated those who had shown minimum level competence. At Level-2 proficiency students are able to account for scientific events in familiar surroundings using everyday or personal knowledge and interpret simple sets of data.

This level of proficiency represents a foundational standard or the bare minimum requirement for scientific literacy. A total of 7,233 students from the Philippines, aged 15, took part in the PISA 2018 cycle. Unfortunately, the country's performance in science was among the lowest compared to other nations. The country's score of 357 was well below the OECD average score of 489. Interestingly, both boys and girls performed similarly, with average performances of 355 and 359, respectively. Just 22% of these students managed to achieve scientific literacy scores at Level 2 or above. By contrast, a significant majority of students from OECD countries achieved Level 2 or above in the scientific literacy assessment, with an average of 78%. Students at Level 2 or higher have the ability to understand and interpret familiar scientific phenomena accurately. With this knowledge, one can determine, in straightforward situations, if a conclusion is sound given the available data.

A significant number of Filipino students have yet to achieve the minimum proficiency level, indicating a concerning level of underperformance. At the most basic levels of proficiency (1A and 1B), students are limited to using their everyday knowledge and skills to describe simple or familiar phenomena. Their grasp of data analysis and scientific investigation needs to be improved (OECD, 2019a, 2019b). The performance of Filipino students in PISA 2018 aligns with their achievement in another international assessment, the Trends in International Mathematics and Science Study (TIMSS). Similar to PISA, TIMSS evaluates students' capacity to utilize their knowledge across various science subjects. The evaluation of performance involved the use of benchmarks, which were assigned scale scores. These scores ranged from low to advanced, with corresponding values of 400, 475, 550, and 625 (Mullis *et al.*, 2020). Fourth-grade Filipino students who took part in the TIMSS 2019 cycle attained an average scale score of 249, which was the lowest among the 58 countries that participated. The overall average score was approximately 491. According to recent findings, most Filipino students demonstrated a limited grasp of scientific concepts and foundational science facts. Only a small percentage of students achieved scores in the low benchmark or higher, indicating the need for further improvement in this area. The consistently low achievement levels in science can be attributed to a combination of different factors that interact with each other.

Past studies utilizing PISA data have aimed to uncover significant factors that distinguish high and low scorers in PISA. As an illustration, Alivernini and Manganelli (2015) examined various factors at the country, school, and student levels to identify the factors that contribute to the disparity in PISA science scores between high and low performers. An analysis was conducted on the PISA 2006 data from 25 countries to determine the factors that could predict high or low proficiency levels. A classification and regression tree analysis were used for this purpose. Teacher salary emerged as the most influential factor at the country level. Parental pressure at the school level has been found to have a significant impact on students' PISA performance. Specifically, the pressure related to the school's standards and size has been shown to influence the performance of students. This suggests that factors such as teacher salaries and school size can play a role in determining students' academic outcomes. Science self-efficacy and awareness of environmental issues were key factors in determining a student's performance in the PISA science assessment at the student level. For this study, we utilize a comparable approach to examine the factors that could shed light on the underperformance of many Filipino students. We analyze the group of students who are not performing well and compare them to those who are performing better. We take into account various factors such as the student's family and home backgrounds, beliefs, goals, attitudes, perceptions, and school experiences. Instead of relying on traditional statistical methods, we employ advanced machine learning techniques to evaluate and differentiate between students who are struggling academically and those who are excelling.

Socioeconomic Status and Educational Inequalities

Research consistently shows that socioeconomic status significantly impacts educational opportunities and outcomes, leading to inequalities in local school provision (Oberti, 2007). These disparities are further exacerbated by social and spatial factors, such as resource distribution and social segregation within education systems (Bénabou, 1994; Burger, 2019). In the US, schools in high-income neighborhoods tend to have more excellent resources and student achievement, highlighting the link between neighborhood and school disadvantage (Owens, 2019). Research in the Philippines has consistently shown a link between socioeconomic status and educational inequalities. Mesa (2007) found that poor provinces have greater education inequality, while Luo (2009) highlighted the role of education in wage differentials, with tertiary education being a prerequisite for high-paid occupations. Manlove (2002) further underscored the impact of social inequalities in urban areas, including ethnicity, gender, and class. However, Huang (2010) found that while schools play a role in student achievement, they account for a relatively small proportion of variance, suggesting that other factors, such as socioeconomic status, also play a significant role. Targeted interventions are needed to address socioeconomic status impact on local educational inequalities. Volante (2010) and Green (2011) both emphasize the need for policies that reduce these disparities, with Volante explicitly pointing to the positive impact of high-quality, publicly funded preschool. Loesch (2018) and Hansen (1972) further explore the complex interplay of factors, such as biased standardized tests and access to resources, that contribute to these inequalities. These studies underscore the urgent need for targeted interventions to address the impact of socioeconomic status on educational outcomes. Numerous studies have established a strong correlation between socioeconomic status (SES) and student achievement in science (Sirin, 2005; Schütz *et al.*, 2008). Students from disadvantaged backgrounds often face obstacles like lack of resources, poor nutrition, and complex home environments that can negatively impact their academic performance (Bramley *et al.*, 2018).. In the Philippine context, the stark economic disparities and high levels of poverty pose significant challenges, as evidenced by the pronounced performance gaps between students from different socioeconomic strata (Albert *et al.*, 2019; Ferrer, 2019).

Educational Policies and Curriculum Design

The development and implementation of educational policies and curricula are critical in shaping scientific literacy outcomes. Effective science curricula should emphasize inquiry-based learning, foster critical thinking, and align with international standards and best practices (Duschl *et al.*, 2007; Osborne, 2014). However, curriculum reforms in the Philippines have often faced challenges in terms of implementation, teacher training, and resource allocation (Bernardo *et al.*, 2008; Ogena *et al.*, 2019). Several studies have highlighted concerns regarding the need for more alignment between curricular objectives and classroom practices, with traditional teaching methods and rote learning still prevalent in many schools (Bernardo *et al.*, 2008; Uy & Malipot, 2022). Additionally, integrating real-world contexts and applications of scientific concepts has been identified as an area for improvement (Ogena & Tan, 2018; Orion & Hofstein, 1994).

According to Uy and Malipot (2022), implementing the K-12 curriculum reform in the Philippines, which aimed to strengthen science education, has faced numerous challenges, including inadequate teacher training, limited instructional resources, and inconsistent implementation across regions and school types. This highlights the need for comprehensive support and monitoring mechanisms for effective curriculum implementation.

Furthermore, Orion and Hofstein (1994) emphasize the importance of aligning science curricula with developing higher-order thinking skills and practical laboratory skills, essential components of scientific literacy assessed by PISA. However, studies have identified gaps in these areas within the Philippine context, suggesting a need for curriculum revisions and enhanced teacher training (Bernardo *et al.*, 2008; Ogena *et al.*, 2019). A comprehensive review and enhancement of the science curriculum is warranted to address these challenges, involving stakeholders from various sectors, including policymakers, educators, and subject matter experts. This should involve aligning curricular objectives and content with the PISA framework, promoting inquiry-based and student-centered pedagogies, and providing adequate instructional materials and resources to support effective implementation (Duschl *et al.*, 2007; Osborne, 2014; Orion & Hofstein, 1994).

Pedagogical Practices and Teacher Quality

The quality of pedagogical practices and teacher competence significantly influence student learning and achievement in science (Kanter & Konstantopoulos, 2010; Supovitz & Turner, 2000). Effective science instruction should promote active learning, hands-on experiences, and the development of higher-order thinking skills (Minner *et al.*, 2010). However, studies in the Philippine context have highlighted concerns regarding traditional teaching methods, limited opportunities for practical experimentation, and inadequate teacher training and professional development (Bernardo *et al.*, 2008; Ogena *et al.*, 2019). Despite efforts to promote inquiry-based and student-centered approaches, traditional teaching methods that emphasize rote memorization and passive learning persist in many Philippine classrooms (Bernardo *et al.*, 2008; Ogena *et al.*, 2019; Rillero, 2016).

Effective science instruction should facilitate active learning, hands-on experiences, and the development of critical thinking and problem-solving skills (Minner *et al.*, 2010; Rillero, 2016). However, studies have highlighted concerns regarding the limited opportunities for practical experimentation, lack of access to laboratory facilities, and inadequate teacher training in inquiry-based pedagogies in the Philippine context (Bernardo *et al.*, 2008; Ogena & Tan, 2018; Rillero, 2016). Rillero (2016) argues that many science teachers in the Philippines rely heavily on traditional lecture-based methods, failing to engage students in active learning experiences. This is often attributed to large class sizes, a need for more resources, and insufficient professional development opportunities focused on innovative pedagogical approaches. Addressing the challenges requires a comprehensive approach, including pre-service teacher education, in-service professional development, and adequate instructional resources and support systems. According to Rillero (2016), teacher education programs should prioritize the development of pedagogical content knowledge, focusing on inquiry-based and student-centered approaches tailored to the Philippine context. This includes equipping preservice teachers with practical strategies for facilitating hands-on activities, promoting critical thinking, and managing inquiry-based learning environments.

Ongoing professional development opportunities, such as workshops, mentoring programs, and collaborative learning communities, can support in-service teachers in continuously enhancing their instructional practices and staying abreast of the latest developments in science education (Desimone, 2009; Rillero, 2016). These initiatives should emphasize practical strategies for implementing inquiry-based pedagogies, integrating technology, and addressing the diverse needs of learners. Furthermore, investment in school infrastructure and laboratory facilities is crucial to facilitating hands-on learning experiences and practical experimentation, essential to effective science education (Glewwe *et al.*, 2011; Lee & Burkam, 2002; Rillero, 2016). The Philippine educational system can better equip students with the scientific literacy skills necessary for success in PISA assessments and beyond by addressing these pedagogical and resource-related challenges.

Cultural and Linguistic Influences

Cultural factors, including societal attitudes, belief systems, and language proficiency, can shape students' interest, engagement, and performance in science (Aikenhead & Ogawa, 2007; Cobern & Aikenhead, 1998). In the Philippines, where multiple languages and cultural traditions coexist, the intersection of these factors with science education warrants further exploration (Bernardo, 2008; Ogena & Tan, 2018).

On the one hand, the rich cultural diversity of the Philippines can serve as a valuable resource for contextualizing science education and making it more relevant and engaging for students. By incorporating local knowledge systems, traditional practices, and culturally relevant examples, educators can create meaningful connections between scientific concepts and students' lived experiences (Aikenhead & Ogawa, 2007; Cobern & Aikenhead, 1998; Tan & Baac, 2022). Tan and Baac (2022) emphasize the importance of adopting a culturally responsive approach to science education that acknowledges and values the diverse ways of knowing and understanding the world. This can foster a more inclusive learning environment, enhance student engagement, and promote a deeper understanding of scientific concepts within cultural contexts.

However, language barriers and cultural differences can also challenge effectively communicating scientific ideas and fostering conceptual understanding (Bernardo, 2008; Tan & Baac, 2022). Students whose first language differs from the language of instruction may need help comprehending scientific terminology and concepts, potentially hindering their performance in assessments like PISA. According to Tan and Baac (2022), the Philippines' multilingual and multicultural landscape necessitates the development of instructional materials and assessments that are linguistically and culturally responsive. This may involve using local languages, culturally relevant analogies, and incorporating indigenous knowledge systems into the curriculum.

A culturally responsive and inclusive approach to science education is warranted to address these challenges. This may involve the development of instructional materials and assessments in local languages, the incorporation of culturally relevant examples and analogies, and the promotion of culturally responsive pedagogies that value diverse perspectives and ways of knowing (Gay, 2018; Ladson-Billings, 1995; Tan & Baac, 2022). Additionally, professional development programs for teachers should prioritize cultural competence and strategies for effectively engaging with diverse student populations (Villegas & Lucas, 2002; Tan & Baac, 2022). By embracing and leveraging the cultural and linguistic diversity of the Philippines, the educational system can foster a more inclusive and contextualized approach to science education, potentially enhancing student engagement, understanding, and performance.

School Environment and Resource Availability

The quality of school infrastructure, availability of instructional materials, and access to educational resources have been linked to student achievement in science (Glewwe *et al.*, 2011; Lee & Burkam, 2002). In the Philippine context, resource constraints and disparities in school facilities and equipment pose significant challenges, particularly in rural and disadvantaged areas (Albert *et al.*, 2019; Ferrer, 2019). Well-equipped science laboratories, up-to-date instructional materials, and access to technological resources are essential for fostering practical skills, conducting experiments, and facilitating interactive and engaging learning experiences (Glewwe *et al.*, 2011; Rodrigo *et al.*, 2020). However, many schools in the Philippines need more critical resources, hindering the effective delivery of science education and limiting opportunities for inquiry-based learning (Albert *et al.*, 2019; Ferrer, 2019; Rodrigo *et al.*, 2020).

Rodrigo *et al.* (2020) state that more adequate science laboratory facilities and equipment are needed to implement inquiry-based and hands-on learning approaches in Philippine schools. Their study found that many schools, particularly in rural areas, need more functional science laboratories or have outdated and poorly maintained equipment, limiting students' opportunities for practical experimentation and scientific inquiry.

To address this challenge, targeted investments in school infrastructure and resource allocation are necessary, particularly in disadvantaged and underserved areas. This may involve upgrading or constructing new science laboratories, providing access to modern instructional materials and technological resources, and ensuring equitable distribution of resources across regions and socioeconomic strata (Glewwe *et al.*, 2011; Rodrigo *et al.*, 2020). By prioritizing the improvement of school facilities and resource access, the Philippine educational system can create more conducive learning environments and enhance opportunities for hands-on, inquiry-based science education, potentially improving student engagement, understanding, and performance in PISA assessments and beyond (Albert *et al.*, 2019; Ferrer, 2019; Rodrigo *et al.*, 2020).

While this literature review provides a broad overview of the potential determinants, it is essential to recognize that these factors often interact in complex ways, and their relative importance may vary across different contexts. The Philippine educational landscape may also present unique challenges and opportunities that require further investigation.

MATERIALS AND METHODS

This research employed a diagnostic inquiry approach to comprehensively investigate the multifaceted determinants behind the Philippines' low PISA science performance. The study begun with an extensive literature review. The researcher meticulously examined PISA reports specific to the Philippines' performance, delving into trends and areas of weakness. Additionally, the review encompassed research on factors influencing scientific literacy development, exploring how students acquire and apply scientific knowledge and skills. To gain further context, the study investigated Philippine educational policies and practices, identifying potential areas for improvement in science curriculum design, pedagogy, and assessment. Finally, the literature review included international comparisons of science education approaches, particularly focusing on high-performing countries and those within the Southeast Asian region, to identify effective strategies that could be adapted to the Philippine context.

Following the literature review, the research proceeded with a secondary data analysis. The researcher meticulously analyzed the Philippines' results from PISA 2018, paying close attention to specific science competencies where Filipino students performed poorly. Additionally, national educational statistics from the Philippine Statistics Authority were examined to understand factors such as student-teacher ratios, classroom resource availability, and regional disparities in educational attainment. Finally, reports from the Department of Education and other government agencies were analyzed to gain insights into existing educational policies, their implementation effectiveness, and potential areas for reform.

To gain a deeper understanding of the issue, the research employed a comparative analysis. The Philippines' performance was compared not only to the OECD averages but also to other participating countries, particularly those within Southeast Asia. This allowed for the identification of both regional trends and potential areas where the Philippines lagged behind its neighbors. Furthermore, the research utilized a multi-level analysis framework. This involved examining factors influencing science achievement at multiple levels: student-level characteristics such as socioeconomic status, motivation, and self-belief in science ability; school-level factors such as resource availability, teacher quality, and instructional practices; and systemic issues like national curriculum design, policy implementation effectiveness, and assessment practices. To ensure a well-rounded understanding, the research adopted an interdisciplinary approach. Insights from educational psychology informed the analysis of student learning processes and how to cultivate scientific thinking skills. The sociology of education shed light on how social factors such as family background and community resources impact student engagement with science. Cultural studies in science education explored the influence of cultural contexts on learning science, considering factors such as language and traditional knowledge systems. Finally, the economics of education was considered to understand how resource allocation within the education system affects science education outcomes.

The research paid particular attention to the unique Philippine context. This involved a thorough examination of how cultural, linguistic, and socioeconomic factors interact and influence science education outcomes. The researcher considered factors such as the emphasis on rote memorization in traditional Filipino classrooms, the potential influence of indigenous knowledge systems on student understanding of scientific concepts, and the socioeconomic disparities that may limit access to quality science education for some students.

Finally, by synthesizing the information gleaned from the literature review, secondary data analysis, and multi-level examination, the research identified the key determinants influencing low PISA science scores in the Philippines. Based on these findings, the study formulated evidence-based recommendations for various stakeholders within the Philippine education system, with the goal of improving science education outcomes and ensuring all Filipino students have the opportunity to develop strong scientific literacy skills.

RESULTS AND DISCUSSION

The findings from this diagnostic inquiry into the underlying determinants of low PISA science performance in the Philippines reveal a complex interplay of socioeconomic, educational, pedagogical, cultural, and resource-related factors contributing to the observed underperformance.

In the PISA 2018 science assessment, the Philippines had an average score of 357, which is significantly below the OECD average of 489. Only about 22% of Filipino students achieved a minimum level of proficiency (Level 2 or higher) in scientific literacy, compared to an OECD average of 78% (OECD, 2019).

Table 1: Results of the PISA scores 2018 and 2022 in all countries and the Philippines

Results of the PISA Scores 2018 and 2022						
	2018			**2022**		
	Population	**Mean**	**S.D.**	**Population**	**Mean**	**S.D.**
Math (Philippines)	7,233	353.00	78	7,193	355.00	65.00
Reading (Philippines)	7,233	340.00	80	7,193	347.00	85.00
Science (Philippines)	7,233	357.00	75	7,193	356.00	78.00
Total Average (Philippines)	7,233	350.00	77.67	7,193	352.67	76.00
Math (All countries)	609,673	454.78	88.9	620,259	437.65	84.88
Reading (All countries)	609,673	453.12	94.64	620,259	435.02	93.85
Science (All countries)	609,673	457.94	89.13	620,259	446.86	89.89
Total average (All countries)	**609,673**	**455.28**	**90.89**	**620,259**	**439.85**	**89.54**

The findings presented in Table 1, which display the PISA scores from 2018 and 2022 for all participating countries, including the Philippines. The trend in the Philippines has already been illustrated in Figure 1 and briefly discussed earlier. In PISA 2018, a total of 609,673 students participated, while in PISA 2022, the number increased to 620,259 across all countries. When comparing the performance of different countries in the PISA assessments, it is interesting to note that the average math scores in 2018 were 454.78, while in 2022, they dropped slightly to 437.65. There has been a decrease of 17.13 points, but its impact is relatively small as the drop in points is not significant. In the reading subject, the numbers for 2018 and 2022 are 453.12 and 435.02, respectively. There has been a significant decrease of 18.76 points in the mean. Finally, Science has a score of 457.94 and a mean of 446.86 for 2018 and 2022 respectively, experiencing a decrease of 11.08 points. Therefore, the scores for all countries that took part in PISA 2018 and 2022 have shown a decrease in the average score across all dimensions. However, the OECD has stated that there is no significant difference in the changes of the scores between PISA 2018 and 2022.

The PISA 2022 assessments were conducted in 2022, but the results are typically released approximately a year after the test administration. The OECD is expected to publish the PISA 2022 results in late 2023 or early 2024. The Philippines scored an average of 357 points in science, which is substantially below the OECD average of 489 points (OECD, 2019a). This places the Philippines among the lowest-performing countries in the PISA science assessment. Only 22% of Filipino students achieved the minimum proficiency level (Level 2) or higher in scientific literacy, compared to the OECD average of 78%. This stark difference underscores the urgent need for targeted interventions to improve science education in the country, as emphasized by Albert *et al.* (2019) and Ferrer (2019). I myself argue that the findings from this diagnostic inquiry into the underlying determinants of low PISA science performance in the Philippines have significant implications for educational policy, practice, and future research directions. The diagnostic inquiry into the underlying determinants of low PISA science performance in the Philippines has revealed a complex interplay of socioeconomic, educational, pedagogical, cultural, and resource-related factors. These determinants do not operate in isolation but rather interact and reinforce one another, creating systemic challenges that require a multidimensional and coordinated approach. The analysis has revealed a complex interplay of socioeconomic, educational, pedagogical, cultural, and resource-related factors contributing to the observed underperformance (Albert *et al.*, 2019; Ferrer, 2019; Ogena *et al.*, 2019). I contend that these determinants do not operate in isolation but rather interact and reinforce one another, creating systemic challenges that require a multidimensional and coordinated approach.

Socioeconomic Disparities and Educational Inequalities

The persistent socioeconomic disparities and educational inequalities in the Philippines highlight the urgent need for targeted interventions to promote equitable access to quality education and mitigate the adverse effects of poverty on student achievement. Schools in disadvantaged and remote areas frequently face greater resource constraints, exacerbating the inequalities in educational opportunities and contributing to the observed achievement gaps in scientific literacy.

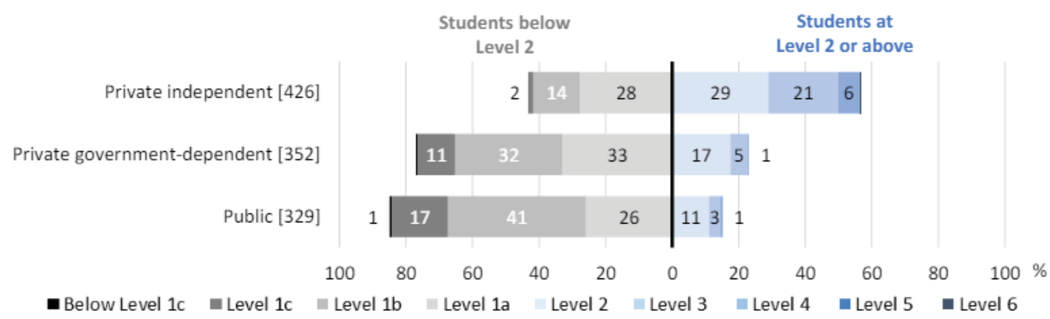

Figure 1: Student proficiency in reading, by school ownership type
Source: OECD PISA 2018 database
Notes: Mean scores are indicated within brackets [ ]
Private independent schools are those that receive less than 50 percent of core funding from government agencies. Private government-dependent schools are those that receive more than 50 percent of the same

As shown in Figure 1, even after accounting for socioeconomic status, there is still a significant disparity in academic achievement between students attending public schools and those in private independent schools. However, the gap does become narrower when comparing public schools to private dependent schools. Once the impact of ESCS was taken into consideration, the difference in performance between students in private government-dependent schools and public schools became much smaller. In reading, the advantage narrowed to just 6 score points, while in math it was only 3 score points, and in science it was just 1 score point. Nevertheless, there was a significant disparity in performance between students attending private independent schools and those in public schools. The former consistently outperformed the latter by a considerable margin, with a difference of 60 score points in reading, 52 score points in math, and 54 score points in math.

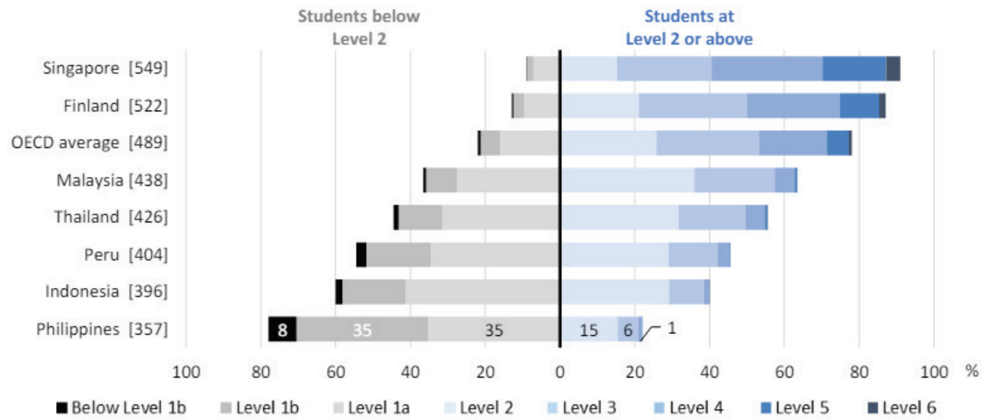

Figure 2: Students' proficiency in science
Source: OECD PISA 2018 database
Notes: Mean reading scores for each country are indicated within brackets [ ]

The PISA 2018 results highlighted in the Figure 2, significant disparities in science literacy performance among Filipino students. The country's average score of 357 was substantially lower than the OECD mean of 489, with only 22% of students attaining minimum proficiency levels (OECD, 2019). While gender differences were minimal, with girls scoring slightly higher at 359 compared to boys at 355 (OECD, 2019), socioeconomic factors played a crucial role. Students from private schools averaged 399, significantly outperforming their public-school counterparts at 347 (Biona, 2019). Regional variations were also evident, with the National Capital Region leading at 391, while rural areas lagged behind urban centers at 333 and 370, respectively (Biona, 2019; Tomacruz, 2019). Moreover, senior high school students demonstrated markedly better performance (439) compared to junior high school students (356), underscoring the importance of sustained investment in quality education (Albert *et al.*, 2019).

Among all countries and economies participating in PISA, the Philippines has the second largest percentage (78 percent) of students who did not meet the minimum proficiency level in science (Figure 2). A significant portion of students in the Philippines achieved Level 1a, with an equal percentage reaching Level 1b. However, a small percentage of students were unable to reach Level 1b. At Level 1a, students are limited to performing basic tasks. They are able to engage in structured scientific inquiries that involve no more than two variables. Additionally, they can recognize simple causal or correlational relationships. At Level 1b, students have the ability to recognize simple data patterns, understand basic scientific terminology, and successfully perform scientific procedures with clear instructions. Students below Level 1b will struggle to solve any of the PISA science tasks, relying mostly on guessing. The persistent socioeconomic disparities and educational inequalities in the Philippines highlight the need for targeted interventions to promote equitable access to quality education and mitigate the adverse effects of poverty on student achievement. I myself argue that the findings from this diagnostic inquiry into the underlying determinants of low PISA science performance in the Philippines have significant implications for educational policy, practice, and future research directions. The analysis has revealed a complex interplay of socioeconomic, educational, pedagogical, cultural, and resource-related factors contributing to the observed underperformance (Albert *et al.*, 2019; Ferrer, 2019; Ogena *et al.*, 2019). I contend that these determinants do not operate in isolation but rather interact and reinforce one another, creating systemic challenges that require a multidimensional and coordinated approach. I emphasize that the persistent socioeconomic disparities and educational inequalities in the Philippines highlight the urgent need for targeted interventions to promote equitable access to quality education and mitigate the adverse effects of poverty on student achievement (Glewwe *et al.*, 2011; Schütz *et al.*, 2008; Sirin, 2005). Policymakers and stakeholders must prioritize initiatives that address these deep-rooted disparities, such as providing financial assistance, improving school infrastructure in disadvantaged areas, and implementing targeted support programs for underprivileged students.

Instructional Approaches and Teacher Expertise

The quality of instructional approaches and teacher expertise in science pedagogy is a critical factor influencing student performance on the PISA science assessment in the Philippines. Traditional teaching methods that emphasize rote memorization and passive learning persist in many Philippine classrooms, hindering the development of critical thinking and problem-solving skills. Addressing these challenges requires a comprehensive approach that targets both pre-service teacher education and in-service professional development, focusing on the development of pedagogical content knowledge and the implementation of inquiry-based and student-centered approaches.

Furthermore, I argue that curricular reforms and teacher professional development initiatives must prioritize the development of inquiry-based and student-centered pedagogies, aligning with the PISA framework and international best practices in science education (Duschl *et al.*, 2007; Kanter & Konstantopoulos, 2010; Osborne, 2014). A comprehensive review and enhancement of the science curriculum, involving stakeholders from various sectors, is warranted to address the identified gaps and promote effective implementation.

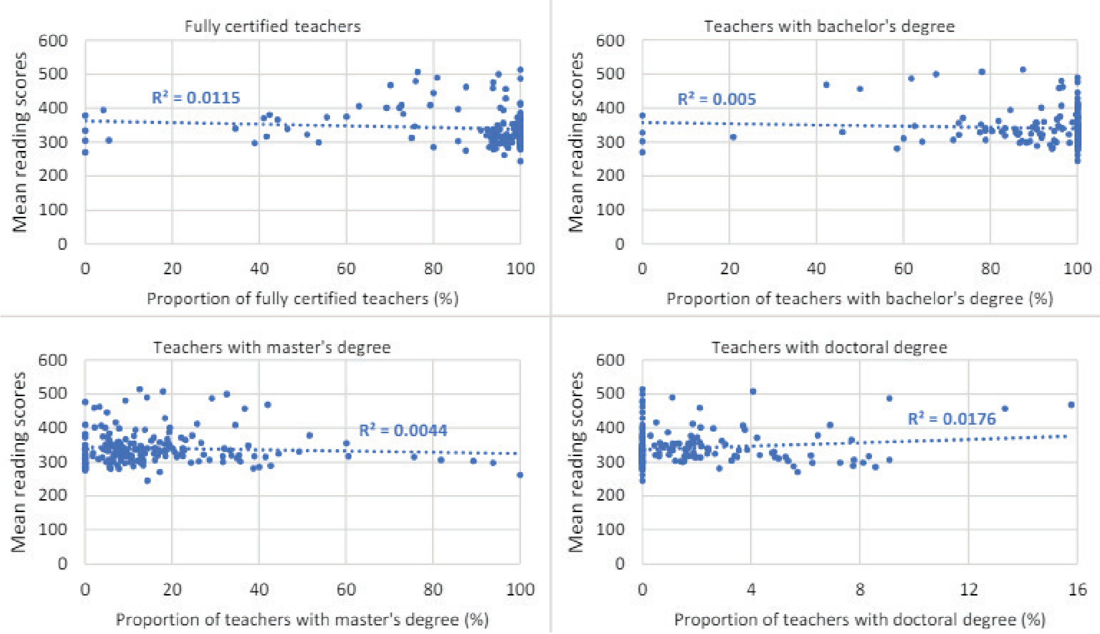

Figure 3: School mean reading scores and teacher qualifications
Source: OECD PISA 2018 database

These findings in Figure 3, indicate the need for a thorough evaluation and enhancement of current screening mechanisms for teachers. It is crucial to ensure that these mechanisms accurately measure and reflect teacher quality. It is generally assumed that individuals who have successfully completed the Licensure Examination for Teachers (LET) possess the necessary skills and competencies required for teaching. It is clear from the evidence that the certification has minimal impact on learning outcomes. This indicates the necessity of evaluating the LET to ensure that the test accurately assesses the knowledge and abilities that teachers should possess. In addition, while certification exams can confirm that individuals possess the necessary knowledge in curriculum and teaching methods, newly-certified teachers may encounter difficulties when faced with the practical aspects of teaching. As an example, Singapore takes a different approach when it comes to evaluating teaching candidates. Instead of relying on licenses or credentials, they have implemented a mandatory probationary period to assess their competence for the job (OECD 2018a). Implementing a mandatory probationary period for all teachers after they pass their certification exams could potentially improve the overall quality of the teaching force.

Cultural And Linguistic Factors

The cultural and linguistic factors influencing science education in the Philippines, as discussed by Bernardo (2008) and Tan & Baac (2022), underscore the importance of developing culturally responsive and inclusive approaches to science education. This includes addressing language barriers and incorporating local knowledge systems and culturally relevant examples into science instruction.

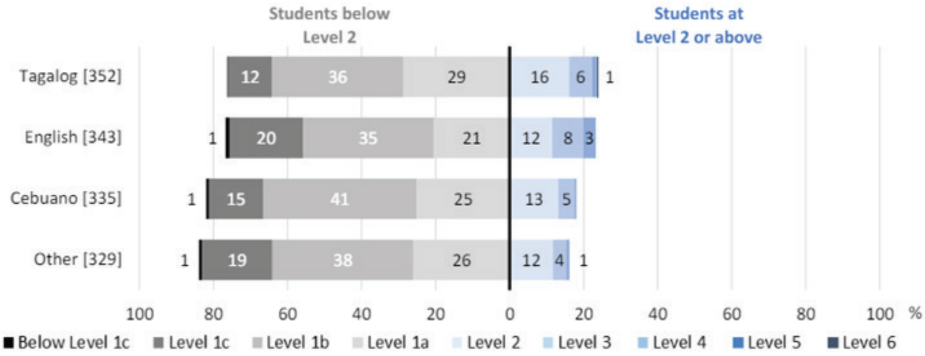

Figure 4: Students' proficiency in reading, by language spoken at home
Source: OECD PISA 2018 database
Notes: Mean scores are indicated within brackets [ ]

According to the data in Figure 4, it is evident that mean scores tend to rise as the duration of early childhood education and care (ECEC) increases. However, this trend only holds true until three years in ECEC. In the Philippines, a large majority of students (90 percent) have participated in ECEC programs for a duration of one to four years. A small percentage of students reported attending ECEC for less than a year, while a slightly larger percentage attended ECEC for more than four years. Figure 19 shows that the majority of students who achieved minimum proficiency spent between three and four years in ECEC. It is interesting to note that a significant portion of students (37 percent) who attended ECEC for just three years were able to achieve at least Level 2 proficiency in reading. By contrast, a significant majority (96 percent) of individuals who had less than a year of experience in ECEC did not meet Level 2 standards. Similarly, those who had over six years of experience in ECEC showed a comparable trend.

Curricular reforms and teacher professional development initiatives must prioritize the development of inquiry-based and student-centered pedagogies, aligning with the PISA framework and international best practices in science education. Furthermore, the Philippines' cultural and linguistic diversity presents opportunities and challenges that necessitate a culturally responsive and inclusive approach to science education. The educational system can foster greater student engagement, understanding, and performance by embracing and leveraging this diversity.

Classroom Ratios in the Philippines

The student-classroom ratios in the Philippines have improved over time, indicating that classroom provision has been outpacing enrollment growth and classrooms are becoming less congested. This progress in reducing overcrowding in classrooms is an important factor for creating conducive learning environments in the Philippine educational system.

Table 2: Classroom-student ratio in the Philippines, SY 2010-2011 to SY 2019-2020

	Elementary	High School	Junior High School*	Senior High School*
SY 2010-2011	1:39	1:53		
SY 2011-2012	1:40	1:53		
SY 2012-2013	1:40	1:51		
SY 2013-2014	1:34	1:49		
SY 2014-2015	1:34	1:48		
SY 2015-2016	1:32	1:35		
SY 2016-2017	1:35	1:39	n.d	n.d.
SY 2017-2018	1.34	1:36	n.d	n.d.
SY 2018-2019	1:28		1:40	1:38
SY 2019-2020	1:29		1:39	1:31

SY = school year; n.d. = no data
** Starting June 2016, high school education consisted of junior high school and senior high school with the additio of Grades 11 and 12 (the senior high school levels) to the basic education system in accordance with the Enhance Basic Education Act of 2013.*
Note on data sources: For SY 2010-2012 up to SY 2014-2015, data on the ratios were given by the NEDA-Socia Development Staff (SDS), citing the DepEd as source. For SY 2015-2016 to SY 2019-2020, data on the ratio were given by the DepEd EMISD-PS.
Sources: NEDA-SDS (2021), DepEd (2021a and 2021b), DepEd EMISD-PS (2022)

The Table 2 above shows that from 39 elementary students per classroom and 53 high school students per classroom in SY 2010-2011, the student-classroom ratios improved to 29 elementary students per classroom, 39 junior high school students per classroom, and 31 students per classroom in SY 2019-2020. This indicates that classroom provision in the Philippines has been outpacing enrolment growth and classrooms are getting less congested. Additionally, I contend that the Philippines' cultural and linguistic diversity presents opportunities and challenges that necessitate a culturally responsive and inclusive approach to science education (Aikenhead & Ogawa, 2007; Cobern & Aikenhead, 1998; Gay, 2018; Ladson-Billings, 1995). By embracing and leveraging this diversity, the educational system can foster greater student engagement, understanding, and performance by developing instructional materials and assessments that resonate with diverse cultural contexts, incorporating culturally relevant examples and analogies, and promoting culturally responsive pedagogies.

Lastly, I argue that addressing resource constraints and disparities in school infrastructure and access to instructional materials is crucial for creating conducive learning environments and facilitating hands-on, inquiry-based science education (Glewwe *et al.*, 2011; Lee & Burkam, 2002; Rodrigo *et al.*, 2020). Strategic investments, partnerships, and resource allocation strategies are essential to ensure equitable access to quality educational resources across regions and socioeconomic strata. Addressing resource constraints and disparities in school infrastructure and access to instructional materials is crucial for creating conducive learning environments and facilitating hands-on, inquiry-based science education. The implications of this diagnostic inquiry extend beyond academic discourse and underscore the need for evidence-based policymaking and targeted interventions. The Philippine educational system can cultivate a scientifically literate and globally competitive workforce capable of driving innovation, economic growth, and sustainable development by addressing the identified determinants.

CONCLUSION

The Philippines' consistent underperformance in the PISA science assessment has raised concerns about the nation's ability to foster scientific literacy and prepare its students for the challenges of the 21st century. This paper has conducted a diagnostic inquiry into the underlying determinants of this underperformance, moving beyond the benchmarking approach that predominates current discourse. Through a critical review of relevant literature and empirical studies, the analysis has delved into the complex interplay of socioeconomic factors, educational policies, pedagogical practices, cultural influences, and resource availability that shape scientific literacy among Filipino students. The findings underscore the systemic nature of the challenges and the need for a multidimensional approach that addresses the identified determinants.

Targeted interventions are required to promote equitable access to quality education, align curricula with international standards, enhance teacher professional development, embrace cultural diversity, and improve school infrastructure and resource allocation. The Philippine educational system can cultivate a scientifically literate and globally competitive workforce capable of driving innovation, economic growth, and sustainable development by addressing these determinants. Ultimately, this diagnostic inquiry contributes to a more nuanced and contextualized understanding of the factors influencing scientific literacy in the Philippines. It serves as a call to action for policymakers, educators, and stakeholders to prioritize evidence-based reforms and targeted interventions addressing the identified systemic challenges. Only through a concerted and collaborative effort can the Philippines unlock the potential of its youth and build a society that values and promotes scientific literacy for all.

Furthermore, sustained political will, adequate funding, and stakeholder collaboration are crucial for these interventions' successful implementation and long-term sustainability. Policymakers, educators, researchers, and industry partners must work together to develop evidence-based solutions tailored to the unique challenges and opportunities within the Philippine context. While addressing the identified determinants is essential for improving PISA science performance, the ultimate goal should be cultivating a scientifically literate and globally competitive workforce to drive innovation, economic growth, and sustainable development. Scientific literacy is a fundamental competency for navigating the complexities of the modern world and actively contributing to societal progress.

This thorough diagnostic assessment aims to provide a more comprehensive and contextualized comprehension of the factors that affect scientific literacy in the Philippines. Its purpose is to urge policymakers, educators, and stakeholders to prioritize data-driven reforms and targeted interventions that address the identified systemic challenges. Achieving this requires a collective and collaborative effort to unlock the potential of the country's youth and establish a society that values and promotes scientific literacy for all.

Looking ahead, continuous monitoring, evaluation, and adaptation will be necessary to ensure that interventions remain relevant and effective in the face of evolving educational landscapes and societal needs. Furthermore, ongoing research and dialogue are essential to expand our understanding of the determinants of scientific literacy and develop innovative strategies for addressing persistent challenges.

The Philippine educational system can lead toward a better student future by adopting a comprehensive and contextual approach. This will enable every student to acquire the scientific knowledge, skills, and mindset required to succeed in a world that is becoming more complicated and evolving at a rapid pace.

RECOMMENDATIONS

I recommend implementing a comprehensive strategy that combines poverty alleviation measures with targeted educational interventions to address the impact of socioeconomic status on scientific literacy outcomes. Specifically:

1. Expanding conditional cash transfer programs to incentivize school attendance and retention among underprivileged students. Evidence from countries like Mexico and Brazil shows these initiatives can improve educational access (Schady *et al.*, 2015).
2. Implementing need-based scholarship programs or tuition assistance to enable students from low-income families to attend well-resourced private or charter schools with strong science programs (Reardon, 2011).
3. Establishing community learning hubs or after-school programs in disadvantaged areas to provide supplemental academic support, access to educational resources, and enrichment activities for underprivileged students (Henderson & Mapp, 2002).
4. Providing comprehensive support services, such as counseling, health care, and social worker assistance, within schools serving underprivileged communities to address non-academic barriers to learning (Rothstein, 2004).
5. Fostering public-private partnerships with corporations, universities, and non-profit organizations to sponsor science outreach initiatives, mentorship programs, and career exposure opportunities targeted at economically disadvantaged students (Ogena *et al.*, 2019).
6. Investing in quality early childhood education programs in disadvantaged communities. As highlighted in the literature (Volante, 2010; Green, 2011), access to high-quality preschool can help mitigate socioeconomic gaps before they widen.
7. Developing contextualized, culturally-responsive science curricula and pedagogies tailored to resonate with students from diverse socioeconomic backgrounds (Deng *et al.*, 2013; Tan & Baac, 2022). This can enhance engagement and conceptual understanding.
8. Providing incentives and support to attract and retain qualified science teachers in underprivileged school districts (Kanter & Konstantopoulos, 2010). This includes competitive compensation, housing assistance, professional development opportunities.
9. Prioritizing investments in science laboratory facilities, instructional materials, and educational technologies in schools serving disadvantaged populations (Rodrigo *et al.*, 2020).
10. Exploring alternative assessment models or culturally-responsive modifications to standardized tests like PISA to ensure equitable evaluation of scientific literacy across diverse socioeconomic contexts (Loesch, 2018; Hansen, 1972).

LIMITATIONS

1. Resource constraints and budget allocations may impede large-scale implementation of costly initiatives like cash transfers, teacher incentives, and infrastructural upgrades, especially in the current economic climate.
2. Deeply-entrenched socioeconomic inequalities and systemic barriers may require long-term, multi-generational efforts to overcome, with improvement in PISA scores being a lagging indicator.
3. Without addressing underlying cultural attitudes, biases, and narratives around poverty and social mobility, educational interventions alone may have limited effectiveness (Bourdieu, 1986; Tan & Barton, 2018).
4. Potential unintended consequences, such as reinforcing stereotypes or creating segregated educational tracks, if interventions are not carefully designed and implemented with equity and inclusion in mind.
5. Difficulty in garnering sustained political support and funding commitments for long-term, multi-generational interventions, given shifting priorities and leadership transitions.
6. Data limitations, such as incomplete poverty statistics, unreliable school-level data, and lack of longitudinal tracking, can hinder accurate needs assessment and monitoring of intervention effectiveness.
7. Challenges in policy continuity, fragmented implementation, and lack of inter-agency coordination can undermine the sustainability and scalability of socioeconomic-focused education reforms across the decentralized Philippine school system.
8. Lack of robust evaluation frameworks and reliable data systems to accurately measure the impact and cost-effectiveness of various interventions, hindering evidence-based decision-making and continuous improvement.

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