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RESEARCH ARTICLE

Assessing Senior High School Students' Awareness of Sustainable Development Goals in a Philippine STEM School

Jericho E. Padilla[1,2], **Jerile Mae E. Casimiro**[1,3], **Carlo V. Amigable**[4]

[1]Department of Science and Technology, Philippine Science High School – Ilocos Region Campus, San Ildefonso, Ilocos Sur, Philippines, [2]College of Education, University of the Philippines Diliman, Quezon City, Philippines, [3]Graduate School, Mariano Marcos State University, Laoag City, Ilocos Norte, Philippines, [4]College of Medicine, University of the Philippines Manila, Manila, Philippines

***Corresponding Author:** padillaje@irc.pshs.edu.ph, jepadilla1@up.edu.ph

ABSTRACT

This study examines senior high school students' awareness and integration of the Sustainable Development Goals (SDGs) within a Philippine STEM school context. Employing a quantitative descriptive design, the research used a structured survey to assess students' self-reported SDG knowledge, information sources, subject penetration, and the impacts on personal lives and career planning, culminating in the development of an Education for Sustainable Development (ESD) model. Findings reveal that formal education is the predominant source of SDG awareness, yet students show limited understanding of the SDGs' temporal and geographic scopes. While subjects such as STEM Research, Social Science, Science Elective, and Science Core exhibit robust SDG integration, disciplines like Mathematics demonstrate significant gaps. Furthermore, path analysis indicates that both self-reported knowledge and information channels play a crucial role in shaping learning outcomes, personal engagement, and future career choices – results that underpin the development of a comprehensive Education for Sustainable Development model. These outcomes advocate for the adoption of innovative, cross-curricular pedagogical strategies, and enhanced career guidance programs to more effectively align sustainability education with national strategic frameworks and prepare students for sustainability-driven professional pathways.

KEY WORDS: Awareness; education for sustainable development; path analysis; sustainability; sustainable development goals

INTRODUCTION

More than halfway through since the Sustainable Development Goals (SDGs) were put into effect, the global roadmap for 15 years collectively orienting the world's efforts toward focusing on addressing numerous socio-economic and environmental challenges, the United Nations (2023) report that there is minimal success in more than half of the SDG targets, with some even showing regression. Alarmingly, global awareness of these goals also remains insufficient (Report of Results Global Survey on Sustainability and the SDGs, 2020). In the school setting, this may indicate the inadequate integration of SDGs into curricula and instructional mechanisms worldwide, posing a threat to the development of essential knowledge and skills needed for today's generation to contribute to sustainability targets.

As educational institutions have an important role to play in shaping the mindset and values of future generations, the objectives of SDG 4 can be a fundamental driver to promote and achieve sustainable development. An effort to advance this goal is the establishment of the Education for Sustainable Development (ESD) by the United Nations as a catalyst for achieving the SDGs among people. This is complemented by key initiatives such as the United Nations Decade of ESD (2005–2014) and the UN Global Action Program on ESD (2014), which have been at the forefront in attempting to transform society toward a sustainable future (Ferrer-Estévez and Chalmeta, 2021). Given these global instruments, researchers are creating educational frameworks that incorporate SDGs into the curricula and instructional practices of educational institutions. But how these models practically apply in schools and universities which are still at an early stage of development and implementation (Filho et al., 2019; Rieckmann, 2017). Therefore, it is imperative to evaluate the progress made in integrating these goals into educational institutions and reinforce the SDG integration.

To synchronize with the Philippines' commitment to the SDGs, the Department of Education implemented the K to 12 Curriculum (Cerezo et al., 2023). The Philippine Science High School (PSHS), under the Department of Science and Technology, transitioned to a 6-year academic program and revised its 2022–2028 strategic frameworks with priority to SDG 13 on Climate Action. The revision introduced three new focus areas: Integrated STEM (inclusivity, climate change, and digital fluency), educational change (project-based learning (PjBL), Filipinnovation, and transformative assessment), and entrepreneurship for community development and sustainability, reinforcing its commitment to SDGs (Habacon, 2023; PSHS, 2023).

In terms of mainstreaming SDGs, most research on SDG awareness is conducted in adult and higher education (Yuan

et al., 2021) with a strong focus on Western countries (Ferrer-Estévez and Chalmeta, 2021; Leiva-Brondo et al., 2022; Smaniotto et al., 2020; Zamora-Polo et al., 2019). Some studies have explored non-Western contexts, such as Nigeria (Omisore et al., 2017) and parts of Asia (Ando et al., 2019; Jati et al., 2019; Novieastari et al., 2022; Yuan et al., 2021), but research on secondary education – especially in Asia – remains limited. Cultural differences, curricular orientations, and local policy mandates can lead to unique outcomes in Asian schools, particularly those specialized in STEM. Consequently, examining senior high school students in such contexts offers insight into how sustainability concepts might be integrated at a younger age and in a non-Western environment.

Through investigating the awareness of SDGs in a Philippine STEM school, this study contributes to the global and national discourse on sustainability education in the basic education, particularly in the secondary level, and nuance our understanding on how STEM-focused curricula and local priorities shape students' knowledge and attitudes in ways that may differ from those in other educational contexts, which includes mainstream secondary schools and university settings. Thus, the findings have significance beyond the local context and offers insights for educators, policymakers, and researchers on the potential of ESD in Asian secondary environments. However, it is important to note certain limitations, such as the focus on a single STEM school and the cultural specificity of the study context, which may affect the broader applicability of the findings. Nonetheless, by comparing institutions and studies from various regions, this research situates itself within the wider literature and highlights its relevance for advancing sustainability education.

LITERATURE REVIEW

SDGs

Launched in 2000 with a target completion date of 2015, the Millennium Development Goals (MDGs) addressed global issues such as poverty, health, and education before being replaced by the SDGs (Suzuki et al., 2015).

Despite significant progress in poverty reduction, education, and healthcare over the 15-year period of MDG, there were still issues toward sustainable development to address (Hajer et al., 2015). This led to the birth of the SDGs during the United Nations Conference on Sustainable Development in 2012, which aims to adopt 17 global objectives to address environmental, political, and economic challenges. The SDGs consist of 17 goals, 169 targets, and 232 unique indicators (Figure 1) in addressing the pressing environmental, political, and economic challenges confronting the world.

Implementing the SDG goals is reliant heavily on national policies, stakeholders' support, and the general public. Through launching initiatives to raise awareness of the SDGs, such as the Sustainable Development Action Campaign, the UN facilitates stakeholder dialog and engagement (Klingspor, 2018; Mulholland et al., 2017). Online data visualization platforms enable global progress monitoring of the SDGs (Rahman et al., 2020). These efforts help the UN strategically meet, communicate, and monitor the SDGs and ensure that they are effectively met and addressed.

The Philippines is working on initiatives to align, advance, and realize the SDGs at national, regional, and local levels. Central to the country's development plans, the Ambisyon Natin 2040 envisions for economic growth, social inclusivity, and environmental sustainability (About Ambisyon Natin, 2016). The program envisions a nation where every Filipino has a strongly-rooted *(matatag),* comfortable *(maginhawa),* and secure *(panatag)* life. This was the framework used for Philippine Development Plan 2023–2028 that aims for economic transformation, translating the Ambisyon 2040 visions into concrete national policies in accordance with the 17 SDGs (Philippine Development Plan 2023–2028, 2023).

Achieving the Ambisyon Natin 2040 requires competent sectors, including education services, to achieve the third vision of smart and innovative Filipinos contributing to improving the quality of life for all. This vision is also aligned with SDG 4, which focuses on quality education and lifelong learning opportunities (Ensure Inclusive and Equitable Quality

Figure 1: The 17 sustainable development goals (United Nations, 2015)

Education and Promote Lifelong Learning Opportunities for All, n.d.). The government has implemented programs and projects to address issues such as poverty, armed conflict, and emergencies, such as exploring alternative delivery modes in the curriculum and offering free tertiary education to all students, all of which contribute to SDG 4.

ESD

Education, as one of the SDGs that aims to empower students to make informed decisions and take responsible actions in support of the environment's integrity and the economy's viability, is the most strategic approach in cultivating and applying the SDG values. It is well-documented how this remains the most effective means of advancing sustainable development and enhancing human potential to address challenges related to the environment and development (Ferrer-Estévez and Chalmeta, 2021; Vilmala et al., 2022; United Nations Educational, Scientific, and Cultural Organization [UNESCO], 2014; cf. Kopnina, 2020). In line with this, the United Nations introduced the ESD, primarily seeking to emphasize competencies that empower individuals to consider their actions' social, cultural, economic, and environmental impacts in promoting sustainable responses in challenging circumstances. ESD equips individuals with knowledge, principles, and dispositions to address local and global issues; and fosters healthy lifestyles and responses to local and global challenges (UNESCO, 2018). Hence, the ESD is a crucial approach in actualizing the SDGs to bring about the changes the society needs to become a sustainable nation (Kioupi and Voulvoulis, 2019).

Schools across the globe are making efforts to embrace ESD, especially in science education. Various studies have looked into several approaches where ESD can be integrated into education. This includes models on how to integrate ESD into curricula, actualizing fusing ESD into the curricula, and assessing the impact of the like in Educational Robotics, Physics, Teacher Education, and STEM courses where students are provided with the opportunity to work on sustainability in a variety of subject areas (Ferrer-Estévez and Chalmeta; Hopkinson and James, 2010; Jauhariyah et al., 2021; Schina, 2020; Suaco, 2024). Teaching strategies and science instructions have also been targeted as one point of integration of ESD like shifting to sustainable experiments and hands-on activities, the use of problem-based learning (PBL) and project-based learning (PjBL) models that take into account stakeholders, pre-existing conditions, and understanding scenarios where it teaches students how to recognize environmental issues, create solutions, and communicate crafted answers (Eilks, 2015; Ferguson et al., 2022; Fredriksson et al., 2020; Schina, 2020; Wals et al, 2016). Other approaches, like the value-based approach, are currently being explored and studied for their potential to promote ESD. While schools worldwide are making efforts to integrate ESD, most empirical research on this topic has been conducted in Western contexts, particularly in Europe (Eilks, 2015; Ferrer-Estévez and Chalmeta, 2021; Fredriksson et al., 2020; Ferguson et al., 2022; Hopkinson and James, 2010; Schina, 2020). Studies in non-Western settings, such as Indonesia (Jauhariyah et al., 2021) and the Philippines (Suaco, 2024), remain fewer in number. This highlights the need for more research exploring how ESD is adapted in diverse cultural and educational contexts, particularly in Asia and other underrepresented regions.

Students' Awareness of SDGs

According to a UN Global Report (Report of Results Global Survey on Sustainability and the SDGs, 2020), there is generally low awareness of SDGs the world over. This report also highlights the importance of SDG 4 Quality Education as one of the three global major concerns of people, together with SDG 13 Climate Action and SDG 3 Good Health and Wellbeing. However, it is important to note that the participants of this survey are primarily from Europe (59%), with only 14% from the Asia Pacific.

In the educational sector, a concerning picture of students' awareness on SDGs can be drawn despite varying initiatives to promote, integrate, and revitalize ESDs in different levels of academia, considering the importance of education in valorizing SDGs (Filho et al., 2019). Studies in higher education institutions indicate that there is generally a low level of knowledge and awareness among tertiary education students on SDGs, or students may be aware of these 17 SDGs but they lack full understanding of these global goals (Ando et al., 2019; Ferrer-Estévez and Chalmeta, 2021; Leiva-Brondo et al., 2022; Novieastari et al., 2022; Omisore et al., 2017; Smaniotto et al., 2020; Zamora-Polo et al., 2019). Furthermore, it is noteworthy to point out that most studies were from European universities, with only few studies from Asia (e.g., Ando et al., 2019; Jati et al., 2019; and Novieastari et al., 2022), and no study of the same character was conducted in the Philippine setting.

While there are many studies at the tertiary level, only a limited number of studies were initiated in basic education. Results of these few studies point out that there is a low level of knowledge and awareness among students, with their knowledge of sustainability dipping during the adolescence period (Olsson and Gericke, 2016; Yuan et al., 2021). On the other hand, several researches also report improved perceptions. Awareness, and understandings of SDGs and other sustainability aspects after the implementation of an SDG focused intervention program or approach (Ian et al., 2019; Koçulu and Topçu, 2024).

In summary, the survey of literature and studies provides a framework on how this study operated in relation to what has been built by previous researchers. Based on this, the researchers identified significant points that are pertinent in this study: (1) The progress of the achievement of the SDGs at an international level; (2) the availability of ESD models and frameworks that integrate SDGs in educational settings but mostly are from Western countries; (3) a good number of surveys and researches on tertiary students' awareness of SDGs, which are mainly from Europe; and the (4) the limited number of studies undertaken in the basic education

on students' awareness of SDGs. Considering these points, this study contributed to studies on students' awareness of SDGs in the Asia and the Philippines, particularly on the basic education level.

Research Questions

This research sought to determine the awareness on SDGs of senior high school students in a Philippine STEM school. Specifically, the following are the research questions of the study:

1. What are the self-reported knowledge and information sources of the students with respect to the SDGs?
2. What is the learning level and subject penetration of SDGs?
3. How do the personal lives of the students affect SDGs, and how will students plan careers related to SDGs?
4. How should the model of ESD for the school surveyed be constructed?

METHODOLOGY

Research Design

The study employed a quantitative descriptive design through a survey questionnaire adapted from the study of Yuan et al. (2021). This approach systematically assesses the knowledge and awareness of senior high school students on 17 SDGs from a Philippine STEM school based in the northern region of the Philippines.

Participants

The survey was conducted at the PSHS – Ilocos Region Campus in San Ildefonso, Ilocos Sur, Philippines. Grade 11 and Grade 12 students of the Specialization Years Program, the equivalent term for senior high school program in the school, participated in this study. A total of 131 senior high school students participated: 60 Grade 11 students and 71 Grade 12 students. The sex distribution comprised 62 males and 69 females, with ages ranging from 16 to 19 (Table 1).

All participants underwent a national competitive screening and came from various provinces in Northern Philippines. Ethical approval (UNP-ERC Approval No. A-2024-093), assent, and consent forms (for minors) were secured to ensure compliance to standards of ethical research practice.

Table 1: Demographics: Percentage and quantity (n=131)

Demographic factor	Percentage (Quantity)
Age	
16	22.9 (30)
17	33.6 (44)
18	40.5 (53)
19	3.1 (4)
Sex	
Male	47.3 (62)
Female	52.7 (69)
Grade	
11	45.8 (60)
12	54.2 (71)

Data Collection Tool

A survey questionnaire adapted from Yuan et al. (2021) formed the core instrument. It consisted of eight parts:

- S0: Demographics (age, sex, and grade level)
- S1: Self-reported knowledge of SDGs
- S2: Sources of information about SDGs
- S3: Learning level of SDGs (involvement of the SDGs in the courses as well as the corresponding subjects
- S4: Subject penetration of SDGs
- S5: Impact of personal lives on SDGs
- S6: Career planning related to SDGs.

Data Collection Procedure

Printed questionnaires, along with assent and consent forms, were administered in homeroom sessions. The questionnaire items were explained verbally to ensure comprehension. Students completed the survey individually under supervision. Completed forms were collected confidentially, and no identifying data were attached to responses.

Data Analysis

Responses were encoded, and surveys with incomplete sections were excluded from the study. A descriptive analysis (mean and standard deviation) was conducted on the demographics (S0) of the respondents, and the overall result of the survey for each section was presented in a table format.

Data on the self-reported knowledge (S1) and sources of information on SDGs (S2) were analyzed by calculating the proportion of each item (weights) for the S1 and S2 questions, which was compared through bar charts where the more students that choose higher values in S1 and S2, the more important the item (Pfeffermann, 1996).

To analyze the learning level of SDGs (S3), the distribution of the responses was first analyzed for its uniformity using the Chi-square goodness-of-fit test (Greasley, 2007; Stockemer, 2019) followed by the calculation of the proportion of selection for each item in S3 to obtain the response and popularity rate across subjects through a bar graph (Zhou, 2017, as cited in Yuan et al., 2021).

For the responses on subject penetration of SDGs (S4), it was analyzed using weight analysis to compare the proportion of students (weights) who learned about SDG in the corresponding subjects (Pfeffermann, 1996).

For the impact of personal life on the SDGs (S5) and their career planning related to SDGs (S6), each used weight analysis on the responses to S5 and S6, respectively, to determine the proportion of students to each item in terms of the impact of personal life on the SDG, and willingness to adopt the corresponding SDG as a personal career choice in the future (Pfeffermann, 1996).

To propose the best-fitting ESD framework using the responses from S1, S2, S3, S5, and S6, the standardized coefficient,

and significance level at α=0.05, were calculated using path analysis to determine the (co-variance) relationship between the five sections using Jamovi 2.5.4 Structural Equation Modeling. The relationship of the sections will be presented in the form of a map supported with the fit indices χ^2/df, RMSEA, CFI, and GFI.

FINDINGS

Table 1 shows that the respondent population consisted of 131 respondents, with the majority aged 18 (40.5%), followed by 17 year olds (33.6%), 16 year olds (22.9%), and a small proportion of 19 year olds (3.1%). The distribution of respondents by sex was nearly balanced, with 47.3% male (62) and 52.7% female (69). In terms of grade level, 45.8% (60) of the respondents were in Grade 11, while 54.2% (71) were in Grade 12. However, it is important to note that since the participation in this study was voluntary, it may have introduced self-selection bias, as students already interested in sustainability may have been more inclined to respond. However, this voluntary nature ensures that responses reflect genuine engagement with SDG topics rather than external influence.

As presented in Table 2, the mean scores of S1 (Self-Reported Knowledge of SDGs), S2 (Sources of Information), S3 (Learning Level of SDGs), S5 (Impact of Personal Life on SDGs), and S6 (Career Planning Related to SDGs) were higher than the median value of "3" on a 5-point scale. These results suggest a moderate to high level of awareness and engagement with SDG topics among respondents.

Weight Analysis of SDG Self-Reported Knowledge and Information Sources

Figure 2 illustrates the results of weight analysis for self-reported knowledge highlighting the varying levels of awareness among students. The higher the weight of the item indicates a significant portion of students who perceive themselves as knowledgeable about a particular item regarding the SDGs, while lower weights may indicate gaps in understanding. The data show that the majority (weight is greater than the mean value) of the senior high school students are knowledgeable about the number of SDGs and are able to indicate one of the goals, and what the 17 SDGs are. However, the respondents show a knowledge gap on the time horizon for which the SDGs are designed, and what countries to which SDGs are addressed.

This distribution may be influenced by the extent to which SDGs are integrated into the curriculum of their subjects as well as the exposure to SDG-related co-curricular or extracurricular activities, with some students having more formal learning experiences or personal engagement with sustainability topics.

Figure 3 presents the weight analysis of different pre-identified sources of information on the SDGs, revealing the primary channels students rely on for learning about sustainability. Higher weights for a specific pre-identified source indicate its key role in SDG awareness. The finding shows that the highest source of the senior high school students is through formal education (30.77%), followed by email and/or social networks (24.77%), and almost similar weights on sources through traditional media (22.28%), and informal training (22.17%). This distribution provides insight into how students in this Philippine STEM school access information about the SDGs and highlights potential areas for enhancing SDG-related education through targeted instructional strategies or broader institutional support.

Analysis of Response and Popularity Rates and Weights on SDG Learning Level and Penetration in Course Subjects

The Chi-square Goodness-of-Fit Test ($\chi 2 = 90.679$; $p = 0.000 < 0.05$) of the data indicated a significant difference in the response which is further presented in response and popularity rate. According to Figure 4, the response rate and popularity rate of SDG penetration were significantly higher in STEM Research, Social Science, Science Elective, and Science Core, in specific order. The high response and popularity rate in STEM Research and Social Science subjects in the school being studied could be associated with the community-based projects and research that students are mandated to complete.

Using weight analysis, Figure 5 illustrates the penetration of SDGs in different subjects. The greater the dark gray bars in this figure, the greater the extent to which students acquired knowledge about SDGs in their subjects. Eight of the 17 SDGs had weights that surpassed the mean weight, to wit: Clean Water and Sanitation, Affordable, and Clean Energy, Climate Action, Good Health and Well-being, Industry, Innovation and Infrastructure, Decent Work and Economic Growth, Quality Education, and Zero Hunger due to the alignment of STEM subjects offered in the school, as mandated by Philippine law to provide "a secondary course with special emphasis on subjects pertaining to the sciences" (Republic Act No. 3661),

Table 2: Mean and standard deviation of each section

Grade	Sex	S1 self-reported knowledge of SDGs	S2 sources of information	S3 learning level of SDGs	S5 impact of personal life on SDGs	S6 career planning related to SDGs
11	Male	3.50±0.97	3.25±0.95	3.48±0.80	3.58±1.12	3.56±0.63
	Female	3.37±0.92	3.32±0.85	3.35±0.98	3.64±0.85	3.34±0.75
	Total	3.43±0.94	3.29±0.89	3.41±0.89	3.61±0.98	3.45±0.70
12	Male	3.53±0.97	3.76±0.87	3.46±0.86	3.70±1.08	3.45±0.81
	Female	3.67±0.75	3.71±0.95	3.88±0.68	3.91±0.75	3.75±0.76
	Total	3.60±0.86	3.73±0.91	3.68±0.80	3.81±0.92	3.61±0.80
Total		3.52±0.90	3.51±0.90	3.55±0.84	3.71±0.95	3.52±0.75

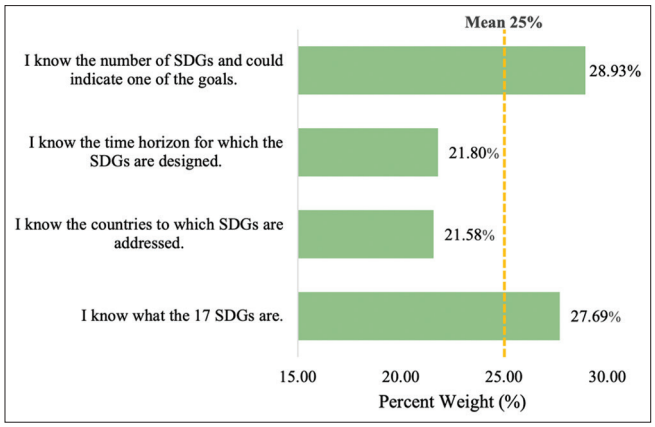

Figure 2: Bar chart of weights for self-reported knowledge of the sustainable development goals

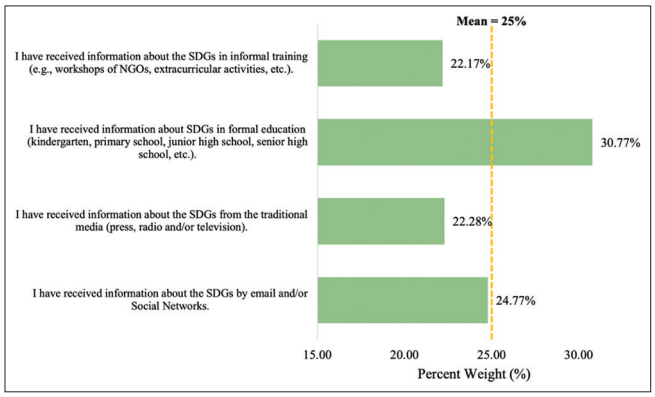

Figure 3: Bar chart of weights for sources of information

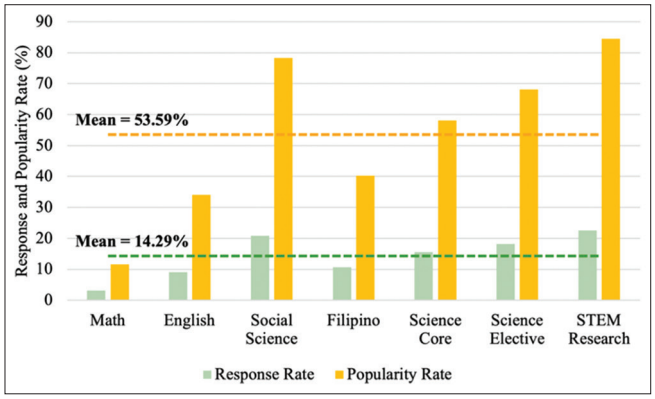

Figure 4: Histogram of response rate and popularity rate of sustainable development goals subject penetration

and consequently, its STEM-focused curriculum framework (Philippine Science High School System, 2023).

In addition, all subjects, except Math, incorporated all SDGs to varying degrees. Specifically, SDG subject penetration was highest in STEM Research followed by Social Science 6 implying the inclusion of SDGs in the instruction and curriculum of the subject (Philippine Science High School System, 2021). Science Elective and Science Core had the third and fourth highest response and popularity rates, respectively, which may be associated with the offered core (Biology and Chemistry) and elective subjects (Design and Make Technologies, Agriculture, Engineering, Computer Science, Biology, and Chemistry) that utilize problem-based and PjBL models, including fieldworks and immersions in their pedagogical and assessment strategies (Philippine Science High School System, 2021).

Analysis of Impact of Personal Life and Career Planning Related to SDGs

In Figure 6, only eight out of 17 SDGs showed greater weight than the mean. Among the highest are Quality Education, Gender Equality, and Climate Action. This implies that students view that their personal lives have the most impact on these SDGs. In contrast, No Poverty, Partnership for Goals, and Zero Hunger have been identified to have been less influenced by the students' daily lives. This result on the impact of one's personal life on SDGs reflects how students perceive and connect these goals to their interests, individuality, and social values, particularly in terms of compassion for others and collaboration to achieve common goals (Yuan et al., 2022).

In Figure 7, the higher mean weight of each SDG indicates the likelihood of the student to pursue a career related to the corresponding SDG. Nine of the 17 SDGs have weight more than the mean, including Good Health and Well-being, Industry, Innovation and Infrastructure, and Decent Work and Economic Growth, while Life Below Water, Zero Hunger, and No Poverty have the least mean indicating the least likelihood of chosen career aligned to these.

As a Philippine STEM school, students are obligated to pursue STEM-related careers in their higher education as stipulated in their contract (Philippine Science High School System Board of Trustees, 2018). With this, careers are prioritized toward Good Health and Well-being, and Industry, Innovation, and Infrastructure as these are where the indicators related to specific competencies of the preferred careers such as Medicine, Healthcare-related professions, and Engineering, are aligned (Zamora-Polo et al., 2019). Contrary to this are low inclination towards social care and some on environmentally relevant careers, likely reflecting the school's strong emphasis on high-demand, policy-driven STEM pathways and limited exposure to how STEM competencies can directly address social and environmental concerns. This selective career choice related to SDGs suggests the need to improve the career guidance program to better support students to be a globally responsible citizen and to have better skill matching in terms of their chosen profession and employment (Alimehmeti et al., 2024). Although for PSHS, this may mean deviating from the approved list of higher education courses to take.

Path Analysis of ESD in the School Surveyed

The best fitting model of the study ($\chi^2/df = 2.10 < 3$; $p = 0.552 > 0.05$) with RMSEA = 0.000, CFI = 1.00, GFI = 1.00 satisfied the accepted values of indicators for a good fit of the model. To investigate further, the standardized path coefficient of the dependent variable to the predictors all showed significant

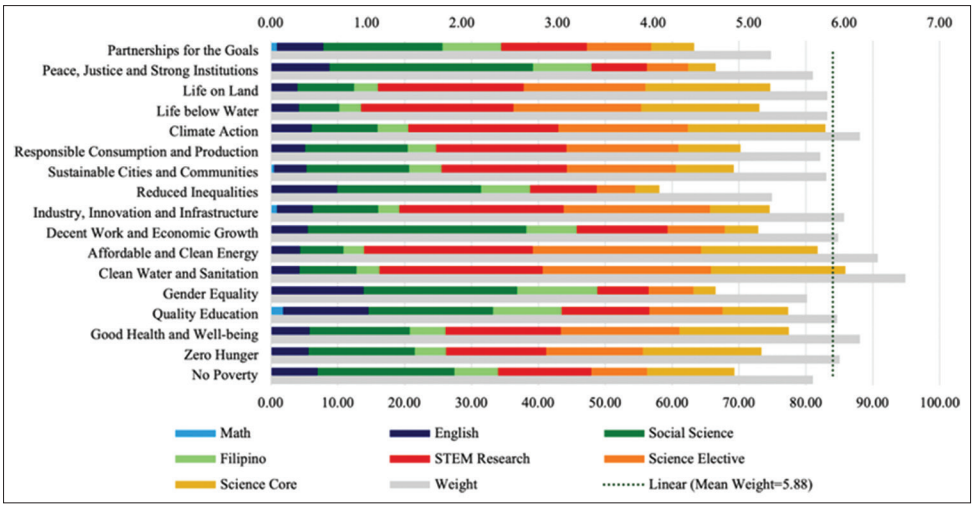

Figure 5: Bar chart of weights for the penetration of the sustainable development goals in different subjects

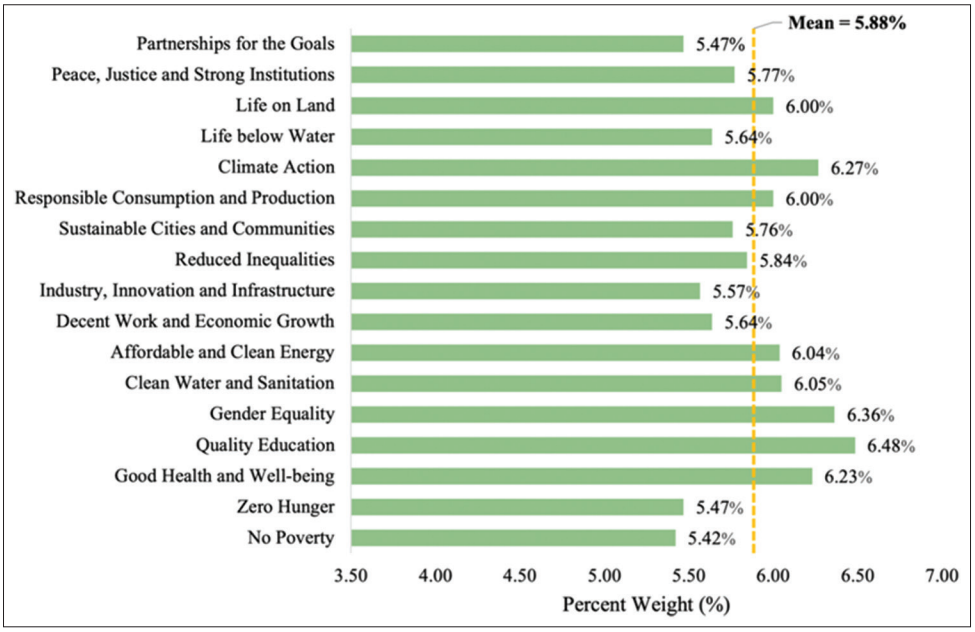

Figure 6: Weight analysis for the impact of personal life on the sustainable development goals

differences. This indicates that Self-reported Knowledge (S1) has a significant positive impact on the Learning Level (S3) of students while Sources of Information (S2) significantly and positively impacts Learning Level and the Impact of Personal Life (S6) of students. Furthermore, the Learning Level of students has a significant positive relationship to Impact of Personal Life and Career Planning (S7) whereas Impact of Personal Life significantly and positively impacts Career Planning. The Self-reported Knowledge and Sources of Information have positive covariance relationship and serve as the predictor variables which directly and indirectly influence the other variables (S3, S6, and S7), implying its impact to the attitudes and behaviors of students toward sustainability (Michel and Zwickle, 2021; Tusoy et al., 2024).

DISCUSSION

Profile of Respondents and Representation

The demographic composition of the respondents in Table 1 provides insight into the distribution of students by age, sex, and grade level, which has significant implications for understanding SDG awareness and learning patterns. The predominance of 18-year-old students suggests that most respondents are nearing the completion of their secondary education, a stage where they may have had greater exposure to academic subjects integrating sustainability concepts. This aligns with studies indicating that older students, particularly those in higher secondary education, demonstrate higher levels of sustainability awareness due to cumulative academic experiences and engagement in interdisciplinary learning frameworks (Olsson and Gericke, 2016; Michel and

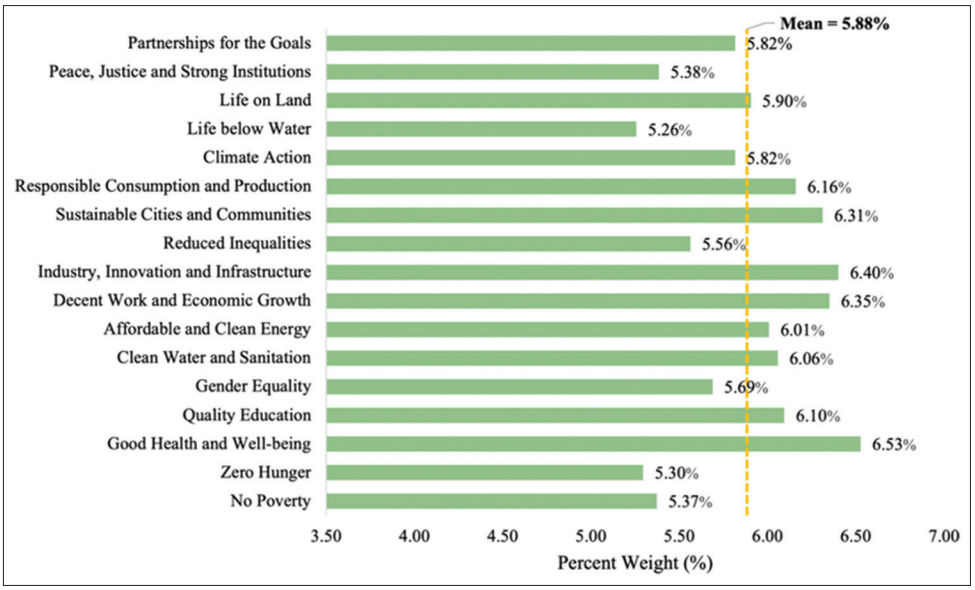

Figure 7: Weight analysis for career planning related to sustainable development goals

Zwickle, 2021). However, the extent of this exposure likely depends on curriculum design, instructional approaches, and extracurricular activities, which were not directly assessed in this study. The inclusion of younger students, such as 16 year olds, offers a comparative perspective on potential differences in SDG awareness across senior high school levels. However, these differences may be influenced by multiple factors, including individual interest, classroom instruction, and external influences, rather than age alone.

The age distribution suggests that younger students may have different levels of engagement and understanding of SDGs compared to older students, consistent with research by Olsson and Gericke (2016), which found that sustainability consciousness evolves with age and educational exposure. The findings contribute to understanding how younger students in Asia interact with sustainability education.

The nearly balanced gender distribution enhances the representation of both male and female perspectives in the findings. However, gender-related biases in sustainability education research may still persist due to broader sociocultural factors, which this study does not explicitly address. A limited number of studies Western higher education settings indicate that female students are generally more engaged in sustainability topics than their male counterparts (Ferreras-Garcia et al., 2021). However, the minimal sex-based differences in the present study suggest that standardized curricular exposure in the Philippine STEM school may have contributed to a more uniform understanding of SDGs across genders, a trend also observed in some non-Western educational contexts (Yuan et al., 2021).

Grade 12 students are exposed to more advanced coursework and PBL, demonstrated a structured understanding of sustainability, aligning with Ferrer-Estévez and Chalmeta (2021), who emphasize progressive learning stages in fostering sustainability consciousness. In contrast, younger students tend to exhibit more flexible attitudes toward sustainability, with structured knowledge developing through academic exposure and research-based coursework (Leiva-Brondo et al., 2022; Omisore et al., 2017). Comparing Grade 11 and Grade 12 students provides insight into how SDG knowledge evolves across secondary education.

As participation was voluntary, self-selection bias may have led to higher engagement from students already interested in sustainability. However, this also ensures genuine engagement with SDG topics. Studies in both Western and non-Western contexts indicate that voluntarily engaged students often demonstrate higher SDG awareness and motivation to apply sustainability principles in their academic and personal lives (Filho et al., 2019; Zamora-Polo et al., 2019).

The demographic data highlights the importance of studying SDG awareness among secondary students, a group often overlooked in existing research (Ferrer-Estévez and Chalmeta, 2021; Leiva-Brondo et al., 2022). Prior studies primarily focus on university students, particularly in Western contexts (Yuan et al., 2021; Ferrer-Estévez and Chalmeta, 2021; Leiva-Brondo et al., 2022; Smaniotto et al., 2020; Zamora-Polo et al., 2019), leaving gaps in understanding how younger students, particularly in Asia, engage with sustainability education.

SDG Awareness and Learning Patterns across Grade and Sex

The findings in Table 2 indicate a moderate to high level of SDG awareness among students, with mean scores above the median value of 3 across all categories, suggesting a moderate to high level of awareness. Grade 12 students demonstrated higher mean scores in self-reported SDG knowledge (S1), sources of information (S2), and learning levels (S3) compared to their Grade 11 counterparts. This aligns with research

indicating that exposure to more advanced academic curricula enhances sustainability consciousness (Michel and Zwickle, 2021). However, Yuan et al. (2021) found that in a Chinese senior high school, Grade 11 students reported greater SDG awareness than Grade 12 students, suggesting that curriculum structure and pedagogical strategies influence SDG learning patterns differently across contexts. In the Philippine STEM school, Grade 12 students' engagement with PBL and PjBL learning frameworks, such as those in Social Science 6 (Philippine Science High School System, 2020), may account for their higher SDG knowledge and learning scores, which were consistent with previous studies that emphasize that these frameworks allow students to consider stakeholders, existing conditions, and various scenarios to equip them with the ability to identify environmental issues, develop solutions, and effectively communicate their responses (Eilks, 2015; Ferguson et al., 2022; Fredriksson et al., 2020; Schina, 2020).

Sex-based differences in SDG awareness were minimal, with male and female students exhibiting similar mean scores across all SDG-related measures. This is consistent with some non-Western studies (e.g., Yuan et al., 2021) as well as certain Western studies (e.g., Leiva-Brondo et al., 2022; Zamora-Polo et al., 2019). The uniformity in SDG exposure among the Philippine STEM students studied may be attributed to standardized curricular structures (e.g., selective nature of the school leading to the homogeneous academic profile of the participants, available curricular, and scholarship support and opportunities) that ensure equal access to sustainability education regardless of sex.

Awareness and Information Sources on SDGs

The findings in Figure 2 indicate that although students possess awareness of SDGs, their depth of knowledge remains uneven, with greater familiarity in identifying SDGs than in comprehending their broader implications. This may imply that many students have surface-level knowledge of SDGs and may not fully understand their meaning and implementation. The findings are similar with global patterns in SDG awareness among students, where familiarity with SDG terminology does not always translate to a profound understanding of sustainability challenges (Leiva-Brondo et al., 2022; Omisore et al., 2017; Smaniotto et al., 2019; Yuan et al., 2021).

As presented in Figure 3, formal education serves as the primary source of SDG knowledge for most respondents, with informal training playing a minor role. This is also the same across various national contexts, such as Romania (Albu, 2022), Spain (Leiva-Brondo et al., 2022; Zamora-Polo et al., 2019), Nigeria (Omisore et al., 2017), and China (Yuan et al., 2021), where sustainability education is primarily delivered through school curricula rather than extracurricular or community-based learning (cf. Al-Nuaimi & Al-Ghamdi, 2022). As underscored by Michel and Zwickle (2021) and supported in earlier literature (Ferrer-Estévez and Chalmeta, 2021; UNESCO, 2014), this places classroom instruction at the center of ESD efforts. In the Philippine setting, the relative emphasis on classroom-based instruction is unsurprising, given the national push for sustainable development through Ambisyon Natin 2040 and the Philippine Development Plan 2023–2028, both of which stress the integration of SDGs – especially SDG 4 – into the educational system (Philippine Development Plan 2023–2028, 2023). In the Philippine STEM school being studied, its strategic framework is anchored on SDGs and the earlier mentioned Philippine strategic frameworks. Thus, strengthening and expanding ESD within formal curricula, including more interactive and project-based approaches (Eilks, 2015; Ferguson et al., 2022; Schina, 2020), could thus deepen students' understanding of the broader implications of sustainability challenges, potentially bridging the gap between basic SDG familiarity and genuine comprehension.

Learning Level and Integration of SDGs across Subject Areas

The findings in Figure 4 – where STEM Research, Social Science, Science Elective, and Science Core register the highest response and popularity rates for SDG penetration – are consistent with the weight analysis results, as shown in Figure 5, which reveal that eight SDGs surpass the mean weight in these same subject areas. In both analyses, the strong integration of SDGs in these subjects reflects the school's STEM-focused curriculum and the community-based projects that students are mandated to complete (Philippine Science High School System, 2021). Courses such as STEM Research and Social Science 6, for instance, adopt problem-based and PjBL models, requiring students to consider stakeholder needs, examine local conditions, and develop practical solutions – approaches aligned with broader ESD strategies (Fredriksson et al., 2020; Schina, 2020). These experiential and inquiry-driven activities naturally embed sustainability concepts, leading to higher student engagement and awareness of the SDGs.

Beyond these core STEM subjects, however, the data indicate that Mathematics and certain language courses show comparatively lower SDG visibility. This corroborates Rajabifard et al. (2021), who note that technical courses – such as Math, Statistics, and Programming – are often perceived as less amenable to sustainability content. Yet, these fields can be powerful vehicles for teaching SDGs through real-world data analysis, scenario modeling, or the design of algorithmic solutions to global challenges. Integrating these methods would expand the reach of SDGs across the entire curriculum and promote a more holistic ESD framework. In line with examples from Singapore's outdoor education (Martin and Ho, 2009; Zguir et al., 2021) and Australia's course-level SDG mapping (Rajabifard et al., 2021), the findings underscore the need for ongoing instructional innovation. With these in mind, it is imperative to rethink pedagogical strategies for every subject – technical or otherwise – and how it can meaningfully contribute to preparing students for the complex sustainability challenges of the future.

Impact of Personal Life on SDGs

The data in Figure 6 indicate that students perceive themselves as having the greatest personal impact on SDG 4 Quality Education, SDG 5 Gender Equality, and SDG 13 Climate Action – all scoring above the overall mean percentage weight. By contrast, SDG 1 No Poverty, SDG 2 Zero Hunger, and SDG 17 Partnerships for the Goals received lower self-assessed impact, suggesting that students see these goals as less directly influenced by their daily actions.

These rankings reflect how closely SDG topics align with young people's experiences, values, and daily decisions (Yuan et al., 2021). Issues such as pursuing quality education, advocating for gender equality in school contexts, and adopting eco-friendly habits feel more actionable at an individual level. As Eilks (2015) argues, when science education connects real-world environmental and social issues to students' lived experiences, learners are more motivated to take responsible action. In addition, Filho et al. (2019) recommend that value of educational interventions that are contextually meaningful, and encourage student participation, and are relevant to students' lives (Yuan et al., 2021).

However, students' lower perceived impact on SDGs related to poverty, hunger, and global partnerships may indicate that these issues may feel more distant or abstract. This can be due to limited direct exposure, media framing, or an educational emphasis on more immediate, personally relevant topics. To address this gap, instructional approaches must create tangible connections to these global challenges. Koçulu and Topçu (2024) emphasize that well-designed, hands-on, and project-based programs can strengthen students' commitment to broad global goals by making abstract concepts more personally significant. This implies that integrating experiential learning opportunities, such as service-learning projects or collaborations with local communities, could enhance students' sense of agency in addressing systemic issues such as poverty and hunger. These findings have important implications for educators and policymakers. If students engage more deeply with SDGs that feel personally relevant, curriculum design should prioritize pedagogical strategies that contextualize global challenges within their lived realities. By doing so, education can develop not only awareness but also a stronger commitment to action across a broader range of sustainability goals.

Career Aspirations and SDG Alignment

The weight analysis for career planning related to SDGs shows a strong emphasis toward careers associated with SDG 3 Good Health and Well-being, SDG 8 Decent Work and Economic Growth, and SDG 9 Industry, Innovation, and Infrastructure. This is a focus stipulated in the revised requirements for Philippine STEM school scholars (Revised PSHS Scholarship Agreement and Updated PSHS List of Approved Science and Technology Courses, 2018). This focus aligns with Suzuki et al. (2015) and Hajer et al. (2015), who argue that national policy directives can strongly influence student perceptions of which fields are most valuable. However, relatively low interest in careers tied to social care and environmental sustainability (e.g., SDG 1 No Poverty and SDG 13 Climate Action) reflects how closely SDG topics align with young people's experiences, values, and daily decisions (Yuan et al., 2021) and their students' lived experiences are related to their real-world environmental and social issues (Eilks, 2015).

Strengthening career guidance initiatives may help students appreciate the societal importance of less-emphasized SDG domains (Alhlimehmetu et al., 2024). Embedding sustainability themes and real-world problem-solving in the curriculum (Eilks, 2015) can expand learners' sense of agency, particularly regarding community development and environmental stewardship (Koçulu and Topçu, 2024).

Educational Pathways for Strengthening SDG Awareness

The pathway model of ESD in Figure 8 indicates that self-reported SDG knowledge (S1) significantly influences learning level (S3), thereby affecting personal life (S6) and career planning (S7). This concurs with studies that students' awareness and understanding of sustainability, often shaped by both curricular and co-curricular experiences, enhance their sense of responsibility toward global challenges (Filho et al., 2019; Olsson and Gericke, 2016; Yuan et al., 2021). In consonance with UNESCO's (2014; 2018) framework for ESD the strong correlation between SDG knowledge and information sources underscores the importance of embedding sustainability education in everyday learning (Michel and Zwickle, 2021; Tusoy et al., 2024). Numerous studies show that integrating SDG-focused lessons fosters not only students' cognitive domain (knowledge of environmental, social, economic, and political dimensions) but also their affective domain (empathy for societal concerns and a sense of agency for local and global issues) (Giangrande et al., 2019; Kioupi and Voulvoulis, 2019). These dual competencies may be further developed through hands-on, learner-centered approaches like problem-based or PjBL (Eilks, 2015; Ferguson et al., 2022; Fredriksson et al., 2020), which stimulate critical thinking and help learners see direct connections between classroom content and real-world sustainability challenges.

Corroborating this emphasis on sustainable competencies, the survey findings suggest that learners' knowledge (S1) and sources of information strongly influence institution-wide SDG awareness. Previous research shows a general lack of SDG familiarity among students in certain contexts (Ando et al., 2019; Ferrer-Estévez and Chalmeta, 2021). Strengthening these knowledge sources through curricular and co-curricular initiatives, such as value-based classroom discussions (Schina, 2020), community-based projects, or digital resource platforms, can provide more meaningful learning experiences, eventually leading to higher-level sustainability competencies and influencing both personal lifestyle choices and career pathways (Novieastari et al., 2022; UNESCO, 2015). This essentially bolsters the vital role of ESD not just in transferring information but also in shaping holistic student development. As learners

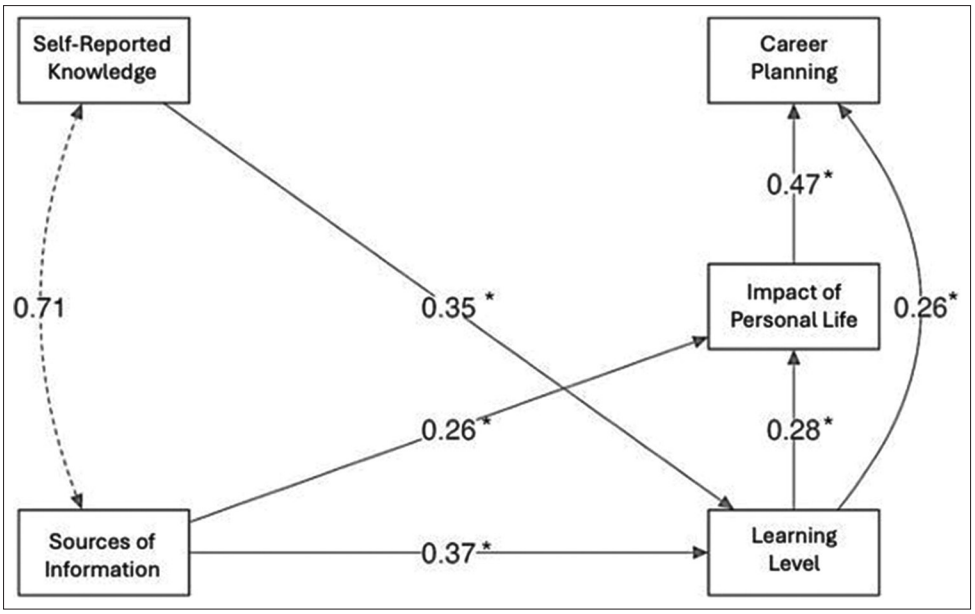

Figure 8: Pathway of education for sustainable development in the school surveyed. *Path coefficient with significant difference ($p < 0.05$) at 0.05 level of significance

become more confident and informed about the 17 SDGs, they are more likely to integrate sustainability considerations into career decision-making, which would help in cultivating the next generation of innovators and leaders who can drive societal transformation toward inclusive and sustainable development (Hajer et al., 2015; Kioupi and Voulvoulis, 2019).

CONCLUSION

This study provides important insights into the awareness and integration of the SDGs in a Philippine STEM school context, an area that has received relatively little attention compared to adult and higher education settings in Western countries (Ferrer-Estévez and Chalmeta, 2021; Yuan et al., 2021). Despite a generally moderate to high level of SDG familiarity, the findings reveal uneven depth of student knowledge and understanding. STEM Research, Social Science, Science Elective, and Science Core subjects exhibit stronger integration of sustainability principles, while technical courses like Mathematics show comparatively limited SDG penetration. This gap points to the need for innovative pedagogical strategies (problem-based and PjBL) to bridge theory and practice and ensure that each subject nurtures meaningful engagement with sustainability challenges (Eilks, 2015; Ferguson et al., 2022).

Moreover, students' self-perceived impact on particular SDGs – especially SDG 4 Quality Education, SDG 5 Gender Equality, and SDG 13 Climate Action – indicates that goals closely tied to personal experience resonate more strongly. In contrast, social welfare and environmental goals such as SDG 1 No Poverty, SDG 2 Zero Hunger, and SDG 14 Life Below Water garner less student attention. Critically, these perceptions also translate into future career preferences, with many learners gravitating toward STEM-related careers aligned with SDG 3 Good Health and Well-being, SDG 8 Decent Work and Economic Growth, SDG 9 Industry, Innovation and Infrastructure, and – reflecting how national policies and local school mandates can shape students' career aspirations (Suzuki et al., 2015; Hajer et al., 2015). Strengthening career guidance programs and embedding more holistic ESD themes into everyday coursework can encourage students to consider a broader range of socially and environmentally oriented professions (Alimehmeti et al., 2024; Koçulu and Topçu, 2024).

Finally, the ESD pathway model developed here underscores how self-reported knowledge and sources of information significantly predict learning outcomes, personal life impacts, and career decision-making. Given the Philippine government's push toward Ambisyon Natin 2040 and the Philippine Development Plan 2023–2028, these findings reinforce the importance of systematic ESD integration at the secondary level. Adopting a whole-school approach – where both curricular and co-curricular activities are explicitly aligned with SDG objectives – can elevate student agency and pave the way for more informed, sustainability-minded graduates (UNESCO, 2014; 2018). Future research can deepen these insights by comparing multiple STEM-oriented institutions across different regions, exploring longitudinal impacts of ESD interventions, and examining how cultural and policy contexts shape students' evolving engagement with sustainability.

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The authors report that there are no competing interests to declare.

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Ethical Approval

The study underwent an ethics review through the University of Northern Philippines - Ethics Review Committee (UNP-ERC) with Approval Number A-2024-093.

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