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PROJECT ECOTOWER: AN ENVIRONMENTAL LEARNING INTERVENTION TO ENHANCE THE LEARNERS' ACADEMIC PERFORMANCE IN EARTH AND SPACE SCIENCE

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ABSTRACT

This study examined the relationship between students' involvement in Project EcoTower, a co-curricular initiative in which students recycle used plastic bottles into vertical gardens, and their academic performance in General Science (Earth and Space Science). A mixed-methods design was used at Sto. Cristo Integrated School, Tarlac City. Of the 200 Grade 12 students in six sections who had participated in the project during Grade 11, 132 respondents were selected through stratified random sampling and answered a researcher-developed five-point Likert questionnaire, and their fourth-quarter grades were obtained from school records. Eighteen participants selected through purposive sampling were interviewed, and the transcripts were analyzed using thematic analysis. Results showed that 75.00% of the respondents obtained Outstanding grades (mean grade = 92.00). Students' involvement in the project was very high (grand mean = 4.41), with learning experiences (4.52), skills development (4.39), and behavioral changes (4.31), and their environmental awareness skills were very high (4.32). Spearman's rho indicated a weak but statistically significant positive relationship between involvement and academic performance ($\rho = 0.254$, $p = 0.005$). The most frequently reported challenges were the need for teacher guidance, difficulty constructing the EcoTower, and balancing the project with other school responsibilities. Themes from the interviews centered on learning through practical application, awareness of plastic waste, collaboration, creativity and problem-solving, waste reduction, and personal environmental responsibility. An action plan addressing the challenges is proposed. Because the design is correlational and the behavioral findings are self-reported, the results do not establish that the project caused improved academic performance.

Keywords: *Project EcoTower, Environmental Education, Project-Based Learning, Academic Performance, Earth and Space Science, Pro-Environmental Behavior, Co-Curricular Activities, Mixed-Methods Research*

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INTRODUCTION

Background of the Study

Science education is crucial because it helps students understand planet Earth, its processes, and its significance. The Senior High School curriculum for General Science, Earth and Space Science equips students with knowledge of the features of Earth that enable life, the greenhouse effect, geological processes, disasters, climate, landforms, and the use of Earth resources. Through the acquisition of these competencies, learners are expected not only to develop a scientific background but also to use their knowledge to solve real-life environmental problems.

A useful strategy for achieving the objectives of the course is the use of co-curricular activities, which are effective in ensuring that students gain the practical experience they need in real-life contexts. Co-curricular activities supplement the educational process by allowing students to apply theoretical knowledge through interactive and cooperative learning. When students are involved in the learning process, they acquire knowledge more successfully and become more motivated.

Project EcoTower is a co-curricular initiative under the General Science Program that aims to put the principles of environmental protection and Earth and space science concepts into practice. The central idea of the project is that students recycle used plastic bottles into vertical gardens, which emphasizes the importance of waste management principles and gives students the chance to apply their knowledge of environmental protection, Earth resources, climate change, and human influence on the environment.

Studies indicate that active student involvement in learning experiences and project-based learning leads to higher motivation, engagement, and academic achievement because learners are able to build their knowledge through meaningful experiences. More specifically, when students participate in ecology projects, they can gain greater scientific understanding, critical thinking, and collaboration skills and become environmentally responsible; thus, students' academic performance in general improves.

Academic performance provides valuable insight into students' learning achievements and their attainment of learning goals in a particular academic field. According to York et al. (2025), academic performance is the measurable level of accomplishment demonstrated by students through their performance in various tests and examinations. In Earth and Space Science, academic performance reflects students' grasp of scientific concepts such as environmental processes, geological phenomena, and sustainability measures. By employing experiential and project-based techniques such as Project EcoTower, it is possible to involve students in the process of studying, allow them to gain meaningful learning experiences, raise their academic performance, and instill in them a responsible approach to the environment.

One effective strategy for promoting environmental awareness is the use of project-based learning and recycling activities in science classes. There has been a shift from teacher-centered to student-centered approaches in the present century (Baysura et al., 2016). One student-centered approach is constructivism, and project-based learning (PBL) is a learning approach that reflects constructivism. PBL comprises challenging questions, sustained inquiry, reflection and critique of work, and production (Grossman et al., 2019). Additionally, PBL is thought to empower students to become global citizens (Alrajeh, 2021).

The use of recyclable materials in classroom activities also supports experiential learning. Recycling projects encourage students to explore environmental solutions while improving practical skills such as problem-solving, communication, collaboration, and creativity. In addition, studies by the United Nations Educational, Scientific and Cultural Organization (UNESCO, 2017) revealed that hands-on environmental activities positively influence students' attitudes and behaviors toward environmental conservation. As Erhabor and Don (2016) explain, environmental programs are also more successful when schools provide adequate support, resources, and opportunities for students to participate actively in environmental activities.

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Research Gap and Rationale

Although environmental and sustainability programs are increasingly used in the school system, little research is available on students' involvement in co-curricular environmental programs and how that involvement affects their academic performance in Earth and Space Science classes. Addressing this gap may provide important information on the benefits of incorporating environmental initiatives into the learning process in science classes and may assist teachers in creating environmentally friendly lesson plans.

Thus, the study investigated how students' involvement in Project EcoTower relates to their performance in Earth and Space Science. The results can be used to improve the development of co-curricular environmental programs and innovative teaching methods that enhance students' performance in this area.

Review of Related Literature and Studies

Environmental education in basic education is a multidisciplinary approach that equips students with the knowledge, skills, attitudes, and behaviors needed to understand and respond to environmental challenges. Research consistently demonstrates that introducing environmental education at the foundational levels of schooling produces lasting academic, social, and behavioral outcomes that extend well beyond the classroom.

Environmental Education

Environmental education is a significant method of achieving environmental awareness, environmental literacy, and sustainable development. The United Nations recognized the importance of the links among these concepts and declared 2005–2014 the "Decade of Education for Sustainable Development." Environmental education, one of the essential elements of sustainable development, helps people and communities develop ecological literacy (Vladova, 2023). The importance of environmental protection and sustainable development has never been higher, and environmental education is essential for educating youth about the significance of ecological protection and for forming the cooperation skills and relationships needed among them.

Environmental Awareness and Environmental Literacy

Although the concepts of environmental awareness and environmental literacy overlap, they are not interchangeable. Environmental awareness is a basic cognitive and emotional state: an understanding of the existence, nature, and seriousness of environmental problems, together with a general emotional concern for the environment (Thomas & Mangai, 2020). It therefore describes not only knowledge of facts but also mental attitudes shaped by environmental literacy. Research indicates that environmental awareness is influenced not by simple knowledge of environmental issues but by environmental literacy, which broadens the concept (Faizah et al., 2023).

The most widely known definition, given by the North American Association for Environmental Education, holds that environmental literacy is awareness of and concern for the environment together with readiness to deal with it in practice. The term was introduced in 1968, but its meaning was clarified considerably after the conferences held in the early 1970s.

Environmental awareness also plays a mediating role within this broader construct. Eleccion and Gallo (2025) found that environmental awareness fully mediates the relationship between science literacy and sustainable practices, accounting for 78.6% of the total effect, which indicates that science literacy enhances awareness, which in turn drives sustainable behavior. This underscores that awareness is not merely a byproduct of knowledge but an active bridge between scientific understanding and responsible action.

Role of Schools in Shaping Pro-Environmental Behavior

Schmitt et al. (2018) suggested that pro-environmental behavior (PEB) is prosocial, meaning that it has positive consequences for others and the environment. If instilled in everyone, such behavior can promote the welfare of living things and the environment around them. Fang (2021) revealed that if pro-environmental behavior elicits feelings of pleasure, intrinsic motivation arises within a person to continue caring for the environment.

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Pro-environmental behavior is action taken to minimize activities that disrupt the balance between nature and living things, thereby maintaining natural harmony and increasing awareness of the importance of protecting the environment. When properly carried out, it ensures a future life in harmony and balance with nature. Pro-environmental behavior is key to environmental sustainability (Křepelková et al., 2020), as it helps sustain the planet, protect natural ecosystems, and maintain the quality of human life. Everyone can play a part in this effort by practicing simple, everyday actions that promote environmental protection and sustainability.

A consistent trend in comparisons of green schools, which are equipped with environmental education curricula, and conventional schools is that children attending green schools demonstrate significantly higher levels of PEB (Djuwita & Benyamin, 2019). However, a special case in Indonesia revealed that the superior behavior was due to social modeling: children attending the green school performed pro-environmental activities automatically by mimicking their friends, without internalizing environmental values or developing a special connection to nature (Djuwita & Benyamin, 2019). On the other hand, public school students were knowledgeable about environmental issues but did not act on that knowledge in their everyday lives because of a lack of practice (Djuwita & Benyamin, 2019). To summarize, schools can train students to be environmentally responsible through the curriculum, but to make behaviors sustainable across contexts, students must also be introduced to internalized values, positive environmental experiences, and reasoning based on acquired knowledge (Djuwita & Benyamin, 2019).

Studies from various contexts show that carrying out education programs and environmental education (EE) alone is not enough. For example, a study of 14 schools in Hungary showed that sustainability conditions can predict students' PEB in real life (Mónus, 2022); green schools possess sustainability infrastructure and EE programs that positively affect students' behavior. When ordinary, green, and persistent green schools in Israel were compared, only persistent green schools showed an immediate positive impact on student behavior, while students from both types of green schools benefited from similar environmental attitude training (Shay-Margalit & Rubin, 2017). Thus, the intensity of training is related to the effect it produces: the more dedicated the program is to the idea of environmental education, the more positive the outcome (Shay-Margalit & Rubin, 2017).

The physical and social environment of schools also matters. A study conducted in a Chinese primary school showed that students' perception of green spaces on school grounds was positively associated with their attitudes toward, and behavior in, environmental protection. In addition, a teacher's example appears to be a more powerful influence than that of peers. Studies show that positive teacher actions, such as picking up litter in front of the children, have a greater effect on children's environmental attention and behaviors than peer influence (Liang et al., 2022). Education for Sustainable Development (ESD) was also found to be very effective in enhancing students' attitudinal and behavioral indicators compared with their levels before the program was introduced (Iqbal et al., 2023).

Integration of Environmental Education in Science Curricula

Integrating environmental education into science curricula poses both a great opportunity and an ongoing structural challenge for basic education systems. Science education is generally regarded as the most suitable location for environmental education within the school curriculum because of the overlap between the two disciplines in ecological concepts, scientific investigation, and understanding of natural systems (Feldman & Nation, 2022). The idea of "greening the curriculum," which brings environmental education principles, ideas, and knowledge into science education and other subjects, is acknowledged internationally as a means of acquiring scientific and environmental literacy at the same time.

Schools are strategic avenues for developing students' attitudes and helping them become active advocates on climate change through increased climate literacy and awareness of climate change–related trends (United Nations Educational, Scientific and Cultural Organization [UNESCO], n.d.). Environmental education in curricular programs enables youth engagement in green growth (Climate Change Commission, 2016), the development of informed decision-making skills, active environmental involvement as influencers, and the adoption of sustainable lifestyles (UNESCO, n.d.). Teaching climate change and helping students understand it is no longer just a matter of scientific interest. Teachers must therefore integrate elements of climate change into their instructional plans

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so that students understand how they can participate, within their capacities, in addressing climate change problems. Students must understand that climate change has consequences for the Earth and for human lives and that they have a vital role to play in addressing its negative effects.

Moreover, teaching about ecosystems as part of environmental education promotes critical thinking about environmental issues and enables learners to look for feasible solutions (Chavula et al., 2024). This approach motivates learners to reflect on how ecosystems work and on what humans can do to worsen or alleviate environmental issues (Piscitelli & D'Uggento, 2022). Learners are thus able to participate actively in sustainability, conservation, and environmental protection. The integration of ecosystem-related education into life sciences education will help the Department of Basic Education create a new generation of educated citizens who are committed to the environment. However, research on the integration of environmental education shows that implementation is moderate but uneven. For example, a study in the Philippines found that various environmental issues were incorporated into different grade levels of the K–12 science curriculum, where teachers used project-based approaches, multimedia, community involvement, and experiential approaches such as clean-ups and tree planting (Buyan & Villocido, 2025). Such actions increased students' environmental awareness. However, the researchers also identified significant hindrances to the full and effective implementation of environmental education (Buyan & Villocido, 2025).

Experiential Learning in Environmental Education

Experiential learning is one of the best-supported methods of environmental education in both theory and practice. Grounded in the theoretical thought of John Dewey, Kurt Lewin, and Jean Piaget, this theory holds that learning is an active rather than a passive process (Miller et al., 2020). Individuals create their own knowledge through various experiences and through reflection on those experiences. In environmental education, this means a shift toward a more learner-centered approach in which students create meaning through direct experience in nature while participating in field trips, community projects, and eco-activities (Hayati, 2020).

Kolb's Experiential Learning Theory. David A. Kolb's Experiential Learning Theory (ELT), formalized in his 1984 book *Experiential Learning: Experience as the Source of Learning and Development*, provides the most widely cited theoretical framework for understanding how direct experience serves as the foundation of knowledge and development (Kolb, 1984; Mughal & Zafar, 2011). Kolb defines learning as "the process whereby knowledge is created through the transformation of experience," and his model rests on six foundational propositions: that learning is a process rather than an outcome; that it is driven by experience; that it requires the learner to resolve conflicts through dialectical reflection; that it is holistic and integrative; that it demands interaction between the individual and the environment; and that it ultimately creates knowledge (Mughal & Zafar, 2011).

Kolb's experiential learning model includes four stages of a cyclical process followed in learning through experience. (1) Concrete Experience: the first step is having a specific experience, such as cleaning up a beach, conducting a water test, or observing nature. (2) Reflective Observation: the student analyzes the experience from different aspects and considers how and why it happened and what it means. At this stage, the emphasis is on the human–nature relationship and the student's position in it. (3) Abstract Conceptualization: the learner forms generalizations or theories based on reflection, integrating observations into conceptual frameworks, for example, by understanding the systemic causes of marine debris or the ecological consequences of waste practices. (4) Active Experimentation: the learner tests new concepts and applies them in new situations, planning and implementing pro-environmental actions. Peer discussion at this stage encourages students to refine their conceptual frameworks and to commit to pro-environmental behavior (Hung et al., 2023).

Research using Kolb's cycle in environmental education shows its effectiveness. Through an experiential-learning-based curriculum about marine debris, researchers found that completing the entire cycle led participants to a more profound understanding of environmental issues, a sense of accountability, greater self-confidence in their analytical skills, and stronger intentions toward responsible action (Hung et al., 2023). Reflection (Stage II) was particularly powerful in fostering awareness of political engagement, while peer discussion (Stage III)

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facilitated the formation of values and behavioral commitment (Hung et al., 2023). Environmental educators in Hong Kong's WWF marine education program similarly demonstrated that applying Kolb's four-stage cycle transformed and internalized students' learning experiences, enhancing their environmental literacy beyond what informational instruction alone could achieve (Wong, 2015).

Kolb's ELT has been adopted as a pedagogical basis for designing, implementing, and assessing outdoor environmental field trips, and research confirms that such programs produce statistically significant changes in students' knowledge of local environments and support their development of both abiotic and biotic ecological understanding (Moseley et al., 2020; Jose et al., 2017). Studies also highlight the cycle's value in fostering critical environmental thinking: when students engage in the full sequence from concrete fieldwork through abstraction and experimentation, they develop not only content knowledge but also the cognitive skills to identify environmental problems in their immediate context and act as agents of change (Escobar, 2019; Gamira & Singh-Pillay, 2020).

Despite its reach, Kolb's model has attracted criticism from the scholarly community. Researchers have pointed out that the cycle falls short in considering the environmental and structural factors that affect a person's learning experience, in addition to psychoanalytic, situated, enactivist, and cultural forces. A reconceptualized model incorporating these inner and outer environmental dimensions suggests that the cycle must acknowledge not only individual cognitive transformation but also the social and cultural contexts in which learning occurs, a dimension especially salient in environmental education, where values, cultural identity, and community norms significantly shape ecological understanding (Mughal & Zafar, 2011).

Learning-by-Doing Approaches: Projects, Recycling, and Eco-Activities

Learning-by-doing approaches in environmental education translate Kolb's theoretical cycle into concrete pedagogical strategies. These include project-based learning (PBL), school recycling initiatives, eco-activities, garden-based programs, and community environmental action projects, all of which share a commitment to placing students at the center of authentic, real-world environmental problem-solving (Yolcu, 2023).

Project-based learning has emerged as one of the most widely researched and recommended active learning strategies in environmental education. In PBL, students work collaboratively over an extended period to investigate and respond to real environmental questions or challenges. A landmark secondary school study in Spain implemented a PBL environmental project in which student groups diagnosed noise pollution, atmospheric contamination, river ecosystems, urban park quality, and tourism impacts in the city of Granada, gathering data through field measurements, citizen interviews, and expert consultations before presenting an urban environment improvement plan to a university audience (Lopez & Palacios, 2020). A pre-test/post-test evaluation revealed a statistically significant improvement in environmental awareness scores ($t = -4.326$; $p < .001$; Cohen's $d = .84$), with gains in the conservation sub-dimension (Lopez & Palacios, 2020). Students reported increased motivation during tasks that required them to interact with external stakeholders, use measurement instruments, and apply scientific skills in real-world contexts (Lopez & Palacios, 2020).

Numerous investigations support these findings. Turkish student teachers who had undergone a PBL environmental science course exhibited significant positive modifications in ecological behaviors relative to baseline data collected before the intervention, confirming that PBL helped close the well-known gap between ecological awareness and behavior change. In primary education, PBL was found to promote students' understanding of how human actions relate to the state of nature and to increase interest in observing correct ecological behaviors in daily life (Pavlova, 2024). An overall systematic review indicates that PBL makes active learning possible and generates cognitive (knowledge) and behavioral (environmental awareness) results that cannot be achieved through passive teaching methods (Yolcu, 2023).

Natural activities and practical environmental tasks such as waste recycling, composting, tree planting, clean-up drives, water-quality detection, and school gardening represent the concrete experience phase of Kolb's process in schools. These activities are valuable not only for their real-world ecological results but also for their teaching

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power: they keep students actively engaged, create links between theoretical knowledge and ecological reality, and enable reflection that lectures cannot achieve (Ballantyne & Packer, 2009; Zalla & Yates, 2020). Studies of educational gardens point to the role of practical components of classes in making students more curious, focused, and engaged (Kline, n.d.).

Moreover, project-based and ecological action approaches are significant because of their cross-disciplinary character. Eco-activities promote integration among science, mathematics, language arts, geography, and civics, which resembles the aims of EE endeavors, as they help students obtain knowledge in a meaningful way and develop interest in the subject (Bramwell-Lalor et al., 2020; Lopez & Palacios, 2020).

Impact of Hands-On Environmental Programs on Student Engagement

The empirical evidence on the impact of hands-on environmental programs on student engagement is strongly positive and spans multiple dimensions of learning: cognitive, affective, social, and behavioral. A central finding across studies is that experiential, place-based environmental programs consistently produce higher levels of student engagement, deeper knowledge retention, and stronger pro-environmental dispositions than conventional, transmission-based instruction (Ballantyne & Packer, 2009; Mansfield, 2023).

A key mechanism linking hands-on environmental programs to engagement is the provision of informal social interaction, freedom of personal choice, and meaningful physical activity. Research synthesizing studies on environmental education programming found that these three factors were critical to children's ability to make meaning from environmental experiences: when students had opportunities to explore, interact with peers spontaneously, and exercise agency over their learning tasks, their engagement and depth of environmental understanding increased substantially (Zalla & Yates, 2020). Conversely, overly structured or exclusively classroom-bound environmental programs produced less sustained engagement, particularly among older students.

Research on outdoor environmental education centers demonstrates the power of experiential, nature-based settings to produce qualitative shifts in students' relationships with the environment. A study of environmental education programs in Queensland, Australia, identified a distinctive fifth pedagogy, experience-based learning, as particularly important for addressing students' environmental attitudes and actions, going beyond the four productive pedagogies identified for classroom learning. In-depth interviews and observations across 12 programs found that the most effective strategies for facilitating environmental learning in natural settings combined direct sensory experience with structured reflection, peer collaboration, and personally relevant ecological investigations (Ballantyne & Packer, 2009).

Hands-on science lessons in middle school contexts show comparably strong effects. A study involving 151 seventh-grade students found that meaningful, hands-on environmental science lessons with relevant content and clear instruction had a long-lasting impact on student learning and engagement, with students demonstrating improved conceptual understanding and heightened personal investment in the discipline (Mansfield, 2023). Coupling hands-on content with local relevance by connecting environmental topics to students' own neighborhoods, rivers, and communities was particularly effective at generating interest, especially among students from historically marginalized backgrounds (Hersh et al., 2025).

One important qualification identified in the literature is that hands-on habituation alone, while effective for short-term behavioral outcomes, does not guarantee the internalization of the pro-environmental values necessary for long-term behavioral sustainability. Programs that couple concrete eco-activities with explicit environmental knowledge instruction, values reflection, and community engagement are more likely to produce graduates who act pro-environmentally not out of habit or external pressure but out of a deep, internalized sense of ecological responsibility (Djuwita & Benyamin, 2019; Hayati, 2020). The most effective experiential EE programs are thus those that move students through the full Kolb cycle, from direct experience through critical reflection and conceptualization to purposeful environmental action, while embedding that cycle within a supportive school culture, qualified teacher facilitation, and authentic community connections.

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Project-Based Learning and Sustainability Initiatives

Utaminingsih et al. (2026) conducted a recent systematic review of PBL and environmental awareness in primary education covering 2020–2025. The effect sizes ranged from 0.52 to 0.96 across the interventions analyzed, and strong school leadership and curriculum flexibility were highlighted as major enabling factors for PBL success in environmental education. Ayerbe-López and Perales (2023) made a significant contribution to qualitative research on the implementation of the Granada urban ecology PBL project through a SWOT analysis of both the high levels of motivation gained and the practical difficulties (e.g., time management, information and communications technology, and teamwork) that teachers faced in implementing PBL. The GAIA energy project (Maurer et al., 2020) introduced an energy-conservation-focused classroom intervention with a pre-post experimental design and found differential learning gains by prior knowledge level, an important equity consideration. Farmer et al. (2019) described an after-school environmental PBL club (Grades 2 to 3) whose scope included recycling, waste disposal, and civic writing, illustrating how environmental PBL can enhance literacy, mathematics, and community involvement from the early grades.

Project-based learning as a strategy in science education. A meta-analysis by Üstün (2019) of 88 primary studies reached a conclusion similar to that of Balemen and Keskin (2018), although it calculated the overall effectiveness at 0.633. The influence of the method on learners' performance in the sciences was significant (0.820), as was its impact on students' attitudes and skills. Wilder (2015) conducted a systematic review of research on the PBL method of teaching for high school students, providing a counterbalance to Üstün's review by acknowledging some limitations of the method with regard to learners' improvement in knowledge. The drawbacks of the approach were also highlighted by Eberlein et al. (2008), who compared PBL with process-oriented guided inquiry learning (POGIL) and peer-led team learning. Musahal et al. (2024) presented STEM-PBL in the study of chemistry, in which problems of waste-acid processing were examined to assess the development of critical thinking.

Student-centered environmental projects. Gallay et al. (2016) conducted a mixed-methods study of more than 240 rural students and showed that place-based stewardship education significantly increased community attachment and civic efficacy, outcomes rarely measured in traditional EE program evaluations. Gallay et al. (2020) and Gallay et al. (2021) together constitute a body of work documenting how place-based civic science in urban schools serving racial and ethnic minority youth builds environmental commons awareness, STEM relevance, and collective agency, making them particularly valuable for equity-focused environmental education research. Schusler and Krasny (2010) developed a conceptual framework showing that environmental action programs produce individual youth development outcomes (competence, self-efficacy, and civic identity) alongside community-level sustainability impacts. Ardoin et al. (2022) provided a systematic review of 60 studies confirming that EE supports all five dimensions of the positive youth development model and identified student-centered activities and experiential environmental action as the two most consistently effective program strategies.

Outcomes of sustainability-driven school programs. Laurie et al. (2016) offered the most internationally representative synthesis, drawing on research from 18 countries, and confirmed that ESD transforms teaching and learning across diverse national contexts. Boeve-de Pauw et al. (2015) used structural equation modeling with 2,413 Swedish students to demonstrate that the degree of holistic and pluralistic ESD teaching directly predicts students' sustainability consciousness, providing unusually strong causal evidence. Torsdottir et al. (2024) presented recent evidence on whole-school approaches from 902 students in Norway and concluded that the ESD curriculum and advanced student participation in school councils are the main aspects of a whole-school approach that enable the formation of action competence. Holst et al. (2024) validated a Whole Institution Approach scale in a large German study (n = 2,985) and showed that implementation of the approach was the strongest predictor of sustainable behavior outside the educational setting, even stronger than sustainability knowledge content. Mónus (2022) introduced socioeconomic background as a moderating variable and found that a school's ESD infrastructure benefits students in higher-socioeconomic-status schools more strongly, raising important equity questions. Spínola (2015), in a comparison of eco-schools in Madeira, Portugal, offered an essential critique: eco-school learners only marginally surpassed students in regular schools in environmental literacy, leading to the conclusion that certification alone does not improve results. Finally, Balundė et al. (2020) described a

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psychological mechanism connecting biospheric values with environmental self-identity and personal norms to various pro-environmental behaviors, thus explaining why school-based sustainability programs may fail to bring about behavioral change even when knowledge increases.

Behavioral Change and Pro-Environmental Attitudes

Green schools provide a form of eco-friendly education whose main goal is to raise environmental consciousness and enhance children's well-being. Green schools take a revolutionary approach by uniting ecological efforts and children's well-being initiatives in education, offering a unique combination of green infrastructure, outdoor spaces, and educational programs focused on eco-sustainability, which studies have shown to be effective in improving cognitive performance, lowering stress, and increasing eco-friendly behavior. Further research should assess the long-term impact of green schools on children's academic success and mental health. Implementing these developments will enhance the lives of students and communities (Blake & Scott, 2024).

Foundational theories: Value–Belief–Norm and Theory of Planned Behavior. Steg and Nordlund (2018) offered a comprehensive theoretical review clarifying that the Theory of Planned Behavior (TPB) focuses on individual cost–benefit calculations, while the Value–Belief–Norm (VBN) theory, drawing on Schwartz's norm activation model, proposes that pro-environmental action stems from moral obligation activated by ecological worldviews and awareness of consequences. Kirby (2020), in a study of 132 undergraduates, found that the combined TPB and VBN model predicted behavioral intentions more accurately than either theory alone, and that different environmental behaviors, specifically direct versus indirect ones, require different theoretical models.

Integrating TPB and VBN. Gkargkavouzi et al. (2019) proposed an integrative model combining TPB, VBN, habits, and self-identity using structural equation modeling. They found that intention was the strongest predictor of environmental behavior, with subjective norm as the main driver of intention, and that awareness of consequences positively influenced attitudes, norms, and perceived behavioral control, outperforming the original model. The meta-analysis of 173 studies by Jebarajakirthy et al. (2024) confirmed this integrated approach: VBN- and TPB-based psychological factors jointly mediate the effects of altruistic, biospheric, and egoistic values on green behavioral intention, with cultural factors moderating these relationships across countries. Raghu and Rodrigues (2021), studying the waste management behavior of 1,105 students, similarly found that an extended TPB and VBN model incorporating environmental knowledge and situational factors achieved superior predictive power compared with the individual theories.

Value–Belief–Norm theory applied to student populations. Liu et al. (2018) tested VBN theory with 1,034 Mongolian college students using structural equation modeling. Altruism had a positive impact on environmental behavior in the public domain, while egoism had a negative one, and the authors claimed that the New Ecological Paradigm mediated the relationship between values and personal norms. Negm (2023) used VBN to study 581 university students in Egypt and found that altruistic and biospheric values shaped personal environmental beliefs, campus norms, and, consequently, pro-environmental behaviors such as recycling and water saving. Liobikienė and Poškus (2019) extended the VBN model by introducing environmental knowledge as an external variable, revealing that action-related knowledge directly influenced private-sphere behavior and that ecological worldview mediated public-sphere behavior, which demonstrates the importance of education for environmental citizenship.

Theory of Planned Behavior in environmental education and school programs. Ting et al. (2025) examined the impact of university environmental conservation courses on students' pro-environmental behavioral intentions using TPB and structural equation modeling with 296 students. Course participation significantly enhanced attitudes, subjective norms, and perceived behavioral control, the three key TPB components, which in turn strengthened behavioral intention toward conservation. Heeren et al. (2016), in a survey of more than 500 university students, found that sustainability knowledge alone had a weak correlation with behavior ($r = 0.113$). When TPB variables (attitudes, norms, and perceived behavioral control) were controlled, knowledge ceased to be a significant predictor, challenging the "knowledge deficit" model and underscoring that fostering behavior change requires addressing social norms and self-efficacy, not just knowledge transmission.

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Theory of Planned Behavior in science mapping and scoping reviews. Zulkepeli et al. (2024) conducted a bibliometric analysis of 1,031 TPB publications on pro-environmental behavior and identified four major research themes: the fundamentals of TPB for environmental behavior, antecedents of pro-environmental behavior, integration of TPB with the norm activation model and VBN theory, and applications in developing countries, with environmental concern, awareness, knowledge, and environmental education as the most commonly integrated variables. The scoping review of 126 TPB publications on conservation behaviors by Yuriev et al. (2020) found that most scholars overlook the importance of identifying indirect belief variables and proposed a four-step roadmap covering framework choice, model extension decisions, methodology, and results reporting to improve the predictive consistency of TPB.

Studies Linking Awareness to Actual Behavior Change

The significance of environmental awareness in encouraging environmental behavior cannot be understated. Environmental awareness implies knowledge of issues and of some solutions to them. Nevertheless, although it seems to be a vital factor, studies illustrate that environmental awareness is not always a reliable predictor of behavior change. For example, Bajracharya and Maskey (2016) argue that students with greater awareness are likely to engage in sustainable practices such as conservation; however, they note that, while awareness can be regarded as a basic factor contributing to environmental responsibility, other psychological and contextual factors may influence behavior, making it inconsistent. Research suggests a positive correlation between environmental awareness and individuals' practices, as demonstrated by studies of Filipino students. For instance, students who were more aware of environmental issues were more active in community actions to protect the environment, such as waste segregation (Reutotar, 2023). This shows that awareness plays an important role in behavioral intentions.

At the same time, studies have shown an awareness–behavior gap, meaning that individuals who know about environmental challenges do not always put their knowledge into action. Reyes and Madrigal (2020) showed that although students were considerably aware of environmental issues, their practices were only moderate, indicating that other behavioral determinants help convert awareness into action effectively. The awareness–behavior gap is a widely discussed issue in environmental psychology: people may understand environmental issues without implementing that knowledge in action. Research has demonstrated that factors such as convenience, social influence, institutional support, and personal motivation come into play when attempting to bridge the gap.

Habit Formation in Environmental Practices Among Students

Recent studies have revealed habit formation to be an important factor influencing students' environmentally friendly actions. A habit is a behavior that has been repeated in similar conditions so many times that it no longer requires conscious effort. According to Tsai and Tan (2022), students who take part in many environmental education activities and sustainability programs acquire stronger environmental habits over time, which are manifested in proper recycling, reduced energy consumption, and less waste. These findings indicate that environmentally friendly actions must be repeated many times to achieve the desired results.

Moreover, behavioral studies show that habits are created when environmental behavior is prompted by stable stimuli such as school rules, workflows, and environmental campaigns. These habits become firmly established and continue to operate with little or no outside support. As Garaialde et al. (2020) found, habit formation leads to behavioral stabilization because of the lower cognitive effort involved. Environmental awareness and habit formation both influence student behavior: while awareness allows students to form an intention, habit formation ensures continuity of action. Students who participate in programs that combine eco-friendly awareness building with frequent behavioral practice are likely to change their behavior in the long term. Awareness provides information, while habit enables a person to apply knowledge in daily life. It can thus be concluded that the best environmental behaviors are achieved through a combination of cognitive understanding and experience.

Recycling Practices in School

Recycling practices in educational institutions significantly contribute to the formation of an environmentally responsible attitude in students. Schools provide an ideal setting for practicing and reinforcing behaviors because

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they are controlled environments in which habits may be formed and strengthened. As Magno (2021) states, recycling practices carried out in educational institutions are important because they influence the level of students' awareness of and involvement in environmental protection. After becoming acquainted with recycling programs, students become more inclined to act in an environmentally responsible manner. The findings of Reyes and Madrigal (2020) also confirm that students taking part in school waste management programs exhibit a higher level of environmental responsibility than those who had no experience of similar programs. Thus, recycling practices in schools help transform acquired environmental knowledge into action.

School recycling programs are implemented in various forms to encourage students and staff members to carry out proper waste segregation and recycling and to become aware of ecological policies. These programs may include recycling bins for segregation, recycling activities, and campaigns aimed at raising ecological awareness. Tsai and Tan (2022) showed that educational programs that include practical recycling activities improve students' environmental behavior; when students participate in school recycling programs, they develop stronger ecological values and act consistently. Moreover, Bajracharya and Maskey (2016) note that institutional help, such as school environmental programs, also plays an important role in promoting students' environmental behaviors. When schools implement recycling programs, they are likely to produce students with a higher sense of environmental awareness.

Recycling should be considered not only an ecological practice but also an effective technique for teaching through experience, as it gives students an opportunity to learn about ecological issues through practice. Studies show that recycling programs increase students' understanding of various ecological issues, including waste disposal and pollution. According to Magno (2021), experiential teaching methods, including recycling, allow learners to retain more ecological knowledge because they become directly involved in obtaining new information. Moreover, Tsai and Tan (2022) showed that students who participate in recycling activities improve their ecological behavior compared with those who receive only theoretical instruction.

Active student involvement is an essential factor in the success of waste management programs in schools, as it allows students to realize that the ecological initiatives designed are also carried out. Reutotar (2023) found that students who actively participate in waste management activities (waste segregation, recycling, and area clean-ups) demonstrate a higher level of ecological responsibility. By promoting participation in environmental activities, schools help students become more aware and responsible. Reyes and Madrigal (2020) similarly emphasize that student participation in environmental programs positively affects ecological practices and promotes behavioral consistency.

Challenges in Implementing Environmental Programs

One of the main barriers to implementing environmental programs in schools is the insufficient availability of funds and materials. Schools encounter challenges in building proper infrastructure such as waste collection bins, recycling equipment, and adequate teaching materials for environmental education (Magno, 2021). Without the right materials, schools struggle to implement proper recycling and sustainability programs, which reduces student engagement (Reyes & Madrigal, 2020). Even when students are aware and ready to participate, they still face difficulties in performing environmentally friendly activities because of infrastructure limitations.

Teacher readiness is one of the important factors that increase the likelihood of successful implementation of environmental education programs. The training teachers receive is crucial for conveying environmental concepts, and, according to Bajracharya and Maskey (2016), the role of educators in enhancing students' environmental consciousness cannot be underestimated. When teachers are not sufficiently trained, they cannot adequately implement sustainable technology in their teaching (Tsai & Tan, 2022). Effective environmental programs clearly require well-trained teaching professionals who can manage and organize experiential learning opportunities such as recycling and waste management.

Another major obstacle to the implementation of any program is students' motivation to become involved (Reutotar, 2023). In addition to properly designed programs, motivational factors influence program effectiveness.

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Reyes and Madrigal (2020) confirmed the importance of motivation and concluded that students' participation in environmental activities depends greatly on their motivation levels and on the importance they perceive in the activities. Students' involvement will be very low if they do not realize the significance of environmental practices in their daily lives. Institutional barriers, defined as the limitations that a school encounters in policy endorsement and program execution, also affect the sustainability of environmental programs. As reported by Magno (2021), schools with strong institutional support succeeded in carrying out environmental programs, whereas schools without a clear set of policies did not sustain proper implementation. Moreover, according to Bajracharya and Maskey (2016), environmental programs require high institutional commitment.

Strategies and Interventions to Enhance Environmental Awareness

Environmental education is critical in providing students with the knowledge, skills, and values to contribute positively to the environment. Effective environmental education involves experiential learning and student-centered teaching approaches and engages students in real-life environmental situations. According to Tsai and Tan (2022), programs that use practical learning approaches in environmental education, such as recycling and waste disposal programs, are more effective in making students adopt environmentally friendly practices because they give students an opportunity to take environmentally friendly actions and not just hear theoretical information. In addition, Magno (2021) concludes that integrating environmental elements into education has a positive impact on students' knowledge of environmental issues; examples of such practices include project-based education, school clean-up initiatives, and recycling programs in which students are involved. Bajracharya and Maskey (2016) point to the role of the social and institutional systems that affect individuals' behavior: the more stakeholders participate in environmental programs, the more likely students are to practice responsible behavior.

Reyes and Madrigal (2020) noted that cooperation between schools and stakeholders plays an important role in the effective implementation of solid waste management programs. Such partnerships allow schools to obtain more resources, assistance, advice, and other stimuli for the further development of environmental education and programs.

Using locally contextualized materials is of utmost importance in environmental education because it makes learning about environmental problems easier. According to Magno (2021), students find it easier to comprehend environmental issues when the issues are presented in relation to their immediate surroundings. For instance, presenting waste-related problems around students in class may have a greater impact on their understanding of the significance of proper waste separation and recycling in their own lives. Tsai and Tan (2022) likewise noted that contextualized environmental education increases students' interest in learning about environmental problems.

Various innovative and affordable environmental education materials are highly effective. For instance, eco-bricks, which are plastic bottles filled with non-biodegradable waste, are now used for building furniture and other objects. According to Reutotar (2023), practical environmental projects based on recycled waste are highly successful in engaging students in sustainable practices.

Student Voice and Participatory Approaches

Student agency means that learners are involved in shaping, engaging in, and taking charge of eco-friendly activities at school. It indicates that students assume the role of active participants in environmental education rather than mere recipients of information. Tsai and Tan (2022) ascertained that environmental education is more effective when students are given the chance to engage in activities that promote sustainability, and students' participation in decisions and actions leads to higher awareness of environmental issues. Magno (2021) found that students' involvement in activities related to environmental issues, such as recycling and waste management, promotes a sense of responsibility among learners.

Youth-led sustainability initiatives involve students in the planning, organization, and execution of activities aimed at achieving environmental goals and objectives. These initiatives promote students' leadership, creativity, and responsibility. According to Reutotar (2023), youth who have been involved in environmental stewardship

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initiatives show very high levels of commitment and awareness. Youth who lead such initiatives tend to behave in more environmentally friendly ways and to influence their peers positively. Bajracharya and Maskey (2016) also pointed out the importance of peer influence and student leadership in shaping environmental attitudes and practices.

Feedback is very important in evaluating the effectiveness of eco-friendly initiatives, as it allows students, teachers, and stakeholders to evaluate what they did successfully and where they can improve. As Reyes and Madrigal (2020) noted, continuous implementation of feedback mechanisms enhances participation as well as program effectiveness. Students need to share their experiences so that initiatives become more responsive to their needs. Moreover, according to Magno (2021), feedback plays a substantial role in improving the methods and approaches used by educators.

Conceptual Framework

The conceptual framework presents the logical sequence of the study, guided by the research problem and its corresponding objectives. The framework is made up of the study's variables and processes, and its structure is composed of three components: Input, Process, and Output (IPO), as shown in Figure 1.

The Input denotes the involvement of students in Project EcoTower. The quantitative data include the academic performance of students, students' environmental awareness skills, the challenges encountered, and the proposed action plan. The qualitative data include the learning experiences of students, skills development, and behavioral changes resulting from engagement in the project.

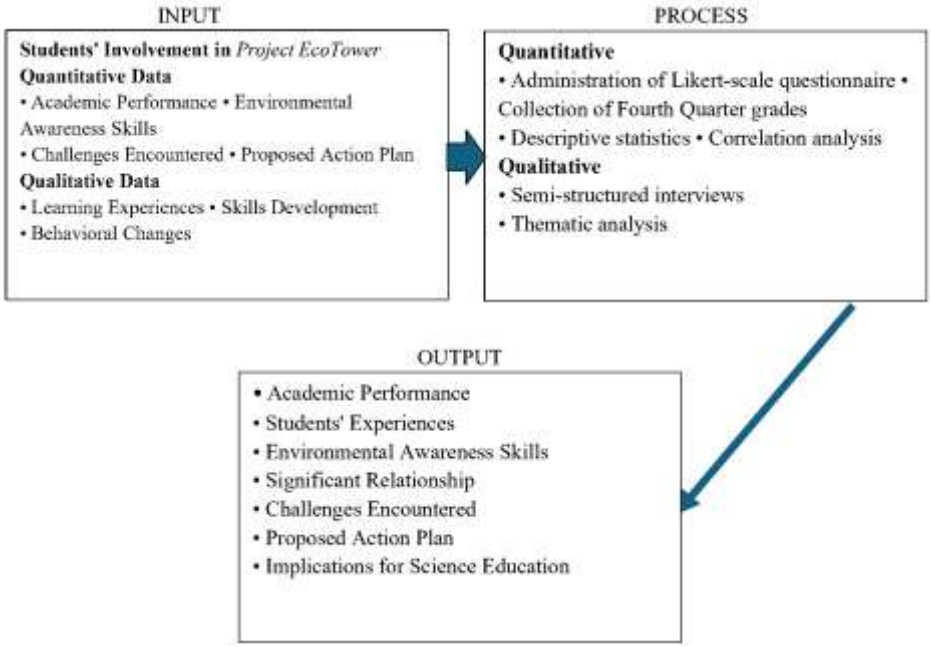
The Process covers both qualitative and quantitative data collection and analysis. The quantitative process includes administering the Likert-scale questionnaire, collecting the fourth-quarter academic performance records of students in General Science (Earth and Space Science), and conducting statistical analysis using descriptive and inferential statistics. The qualitative process includes conducting semi-structured interviews and analyzing the responses through thematic analysis. The qualitative and quantitative findings are then combined into one set of conclusions.

The Output includes the results of the study, which comprise the academic performance of students, students' experiences, skills acquired in environmental awareness, the relationship between students' involvement in the project and their academic performance, the challenges encountered during the project, the proposed action plan, and the conclusions for science education.

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Figure 1. Paradigm of the Study



Statement of the Problem and Objectives

The study sought to examine the relationship between students' participation in Project EcoTower and their academic performance in General Science, particularly in Earth and Space Science. Specifically, it sought to answer the following questions:

1. What is the academic performance of Grade 11 students in General Science (Earth and Space Science) during the fourth quarter?
2. What is the level of students' involvement in Project EcoTower in terms of (2.1) learning experiences, (2.2) skills development, and (2.3) behavioral changes?
3. What environmental awareness skills did the students develop through their involvement in the project?
4. Is there a significant relationship between the students' involvement in Project EcoTower and their academic performance in General Science (Earth and Space Science)?
5. What challenges did the students encounter while participating in the project?
6. What action plan can be proposed to address the challenges encountered by the students during the project's implementation?
7. What are the implications of the findings for science education and the implementation of co-curricular environmental projects?

Significance of the Study

This study aimed to determine the relationship between students' involvement in Project EcoTower and their academic performance in Earth and Space Science. The results are expected to provide valuable insights and benefits to the following:

Students. The findings may help students recognize the value of actively participating in co-curricular environmental projects in enhancing their understanding of Earth and Space Science concepts, developing environmental responsibility, and improving their academic performance.

Science Teachers. The study may help science teachers discover how project-centered and extracurricular activities enhance instruction and create effective learning practices. It has great potential to initiate improvements in other project implementations in the future.

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School Administrators. The results can be of great significance to school administrators in developing environmental programs in schools and implementing activities that lead to both educational performance and environmental responsibility.

Curriculum Planners and Education Leaders. The study may provide evidence on the educational value of integrating environmental projects into the General Science curriculum. It may serve as a reference in designing learning experiences that foster both scientific knowledge and environmental awareness.

Future Researchers. This study may serve as a useful reference for future researchers who wish to conduct similar studies on project-based learning, environmental education, co-curricular activities, and their relationship to students' academic performance.

Scope and Delimitation

This study focused on determining the relationship between students' involvement in Project EcoTower and their academic performance in General Science (Earth and Space Science). Project EcoTower allowed students to recycle plastics to grow plants.

The respondents were limited to selected Grade 12 students of Sto. Cristo Integrated School who participated in Project EcoTower during their Grade 11 General Science classes in School Year 2025–2026. These students were selected because they had firsthand experience implementing the project and had already completed the Earth and Space Science competencies covered during the fourth quarter.

The study examined the students' involvement in the project in terms of learning experiences, skills development, and behavioral changes, as well as the environmental awareness skills they developed through participation. The students' academic performance was assessed based on their fourth-quarter grades in General Science (Earth and Space Science) for School Year 2025–2026.

The study was limited to the selected student respondents from Sto. Cristo Integrated School and does not include students from other schools or those who did not participate in the project. Furthermore, the findings were limited to the variables included in the study and should not be generalized beyond the research context and population.

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METHODS

This section describes the research methods and procedures used in the study. It presents the research design, research environment, participants, research instruments, data-gathering procedure, data analysis, and ethical considerations. These components serve as a framework for collecting, analyzing, and interpreting information to determine whether there is a relationship between students' participation in Project EcoTower and their academic performance in Earth and Space Science.

Research Design

The study used a mixed-methods research design that included both quantitative and qualitative methods to give an in-depth understanding of the research problem. Creswell and Creswell (2023) stated that this type of research combines quantitative and qualitative data collection and analysis within one study so that a complete understanding of an issue can be achieved. Because numerical information is complemented by participants' experiences, this design allows a better interpretation of the research findings.

The quantitative approach was used to gather and analyze numerical data by means of an author-designed questionnaire with a five-point Likert scale. Creswell and Creswell (2023) defined quantitative research as a method aimed at testing objective theories by analyzing relationships among variables using numerical data and statistics. In this study, the quantitative approach was applied to measure students' academic performance, environmental awareness skills, and challenges encountered, and the relationship between student participation in Project EcoTower and academic performance in Earth and Space Science.

The qualitative method was used to understand participants' experiences of being involved in the project. Qualitative research is an approach that aims at understanding the meaning that people or groups of people assign to social or human problems through the collection and analysis of non-numerical data. In this study, semi-structured interviews were held to obtain detailed information on students' learning experiences, the skills they acquired, and the behaviors influenced by being part of Project EcoTower. Combining the quantitative and qualitative findings provides statistical evidence as well as specific information about students' involvement in the project.

Research Environment

The research took place at Sto. Cristo Integrated School, situated at Juan Luna Street, Barangay Sto. Cristo, Tarlac City. The school is a public secondary educational institution under the Department of Education and offers the Senior High School program, including General Science. Project EcoTower is implemented as a co-curricular activity in the Grade 11 General Science (Earth and Space Science) course. The project allows students to gain knowledge in the field of ecology and to apply it in practice in dealing with environmental protection by using plastic bottles for vertical gardening.

Participants of the Study

The respondents of this study were the Grade 12 students of Sto. Cristo Integrated School who participated in Project EcoTower during their Grade 11 General Science class in School Year 2025–2026. The total population consisted of 200 students from six Grade 12 sections. The minimum sample size for the quantitative component was determined using Slovin's formula:

$$n = \frac{N}{1 + Ne^2}$$

where n is the sample size, N is the population size, and e is the margin of error (0.05). Using Slovin's formula, the computed minimum sample size was 132 respondents. To ensure equal representation from each of the six Grade 12 sections and to strengthen the reliability of the quantitative findings, the researcher selected 22 students from each section through stratified random sampling. The six sections were Faulkner, Amorsolo, Vygotsky, and

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Montaigne (students from the Arts, Social Sciences, and Humanities [ASSH] strand) and Nightingale and Archimedes (students from the Science, Technology, Engineering, and Mathematics [STEM] strand).

For the qualitative component, a total of 18 participants were chosen using purposive sampling, consisting of three students from each section. The selection was based on their active participation in Project EcoTower and their capacity to share relevant and in-depth insights regarding their experiences throughout the project's implementation.

Research Instruments

The study employed two research instruments corresponding to the quantitative and qualitative components. The first was a researcher-developed questionnaire for the quantitative component, which comprised four parts aligned with the research objectives. Part one measured students' academic performance. Part two measured the level of awareness achieved through participation in Project EcoTower. Part three evaluated the challenges faced by the students during project implementation. Part four collected students' opinions on the action plan. All items in the questionnaire used a five-point Likert scale to measure participants' level of agreement with the statements provided.

The second instrument was a semi-structured interview guide developed for the qualitative phase of the study (see Appendix A). The guide contains questions about students' experiences in Project EcoTower, including the skills acquired, learning outcomes, and behavior modifications resulting from participation in the project. It gave respondents the opportunity to speak about their experiences while providing the researcher with the information necessary for the study. Prior to data collection, both instruments were validated by experts in science education and educational research to ensure that they were appropriate, comprehensible, and relevant.

Data-Gathering Procedure

The researcher secured formal permission from the Office of the School Principal of Sto. Cristo Integrated School to conduct the study. Upon approval, permission was obtained from the concerned teachers to conduct the study among the selected respondents. The researcher explained the purpose and procedures of the study to the participants and distributed informed consent forms; for participants below eighteen (18) years old, parental or guardian consent was likewise secured before data collection.

For the quantitative component, the researcher selected the respondents through stratified random sampling and personally administered the researcher-made questionnaire. Adequate time was provided for the respondents to complete the instrument, after which the completed questionnaires were collected, checked, and organized for analysis. The students' fourth-quarter grades in General Science (Earth and Space Science) for School Year 2025–2026 were obtained from official school records upon approval by the school administration.

In the qualitative component, purposive sampling was employed to select three participants from every Grade 12 section. The semi-structured interviews took place at a mutually agreed-upon time at the school. The participants agreed that all interviews would be audio-recorded to ensure the authenticity of the interview data. The recorded interviews were transcribed completely and analyzed afterward. Once both the quantitative and qualitative data had been collected, the researcher organized, categorized, and analyzed them using appropriate statistical and qualitative data analysis methods.

Data Analysis

The quantitative data were analyzed using descriptive and inferential statistical techniques. The students' academic performance was described using the mean and standard deviation. The grading descriptors and scale were adapted from the Department of Education's grading framework under DepEd Order No. 8, s. 2015, with consideration of the Interim Guidelines under DepEd Memorandum No. 74, s. 2025 for the pilot implementation of the Strengthened Senior High School Curriculum. The basis for interpreting academic performance is shown in Table 1.

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Table 1. Basis for Interpreting Academic Performance

Grade Percentage Range	Adjectival Grade
90% and above	Outstanding
85–89%	Very Satisfactory
80–84%	Satisfactory
75–79%	Fairly Satisfactory
Below 75%	Failed

The weighted mean was used to analyze the level of students' involvement in Project EcoTower, and the scale in Table 2 was used as the basis for interpretation.

Table 2. Scale for Interpreting the Level of Students' Involvement in Project EcoTower

Scale	Range	Interpretation
5	4.21–5.00	Very high
4	3.41–4.20	High
3	2.61–3.40	Moderate
2	1.81–2.60	Low
1	1.00–1.80	Very low

Likewise, the weighted mean was used to analyze the level of awareness skills that students developed through their involvement in the project. A five-point Likert scale was also used, as shown in Table 3.

Table 3. Scale for Interpreting the Level of Environmental Awareness Skills

Scale	Range	Interpretation
5	4.21–5.00	Very highly aware
4	3.41–4.20	Highly aware
3	2.61–3.40	Moderately aware
2	1.81–2.60	Slightly aware
1	1.00–1.80	Not aware

To determine the significance of the relationship between students' involvement in Project EcoTower and their academic performance in Earth and Space Science, Spearman's rho was used rather than Pearson's *r* because of the skewed distribution of the variables. Unlike Pearson's correlation, which measures linear relationships using exact numerical values, Spearman's rho measures monotonic relationships by converting raw data into ranks before calculating the correlation. A monotonic relationship means that as one variable increases, the other variable consistently increases or decreases, even if not at a constant linear rate.

For the qualitative component, the interview transcripts were analyzed using thematic analysis following the six-step framework cited by Mortensen (2020):

1. **Familiarization.** The researchers reviewed all gathered data, including recordings and transcriptions, and began taking notes, from which preliminary ideas for codes were made.
2. **Generating initial codes.** The researchers assigned codes to the derived data.

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3. **Searching for themes.** The researchers sorted the codes into themes by reviewing the list of codes and their associated extracts and collating the codes into broader themes.
4. **Reviewing themes.** The researchers reviewed and refined the themes identified in the previous step to ensure that each was supported by the data.
5. **Defining and naming themes.** The researchers named and defined the themes.
6. **Producing the report.** After devising the codes and themes, the researchers wrote the report.

Lastly, the quantitative and qualitative results were combined during the interpretation phase to provide a comprehensive understanding of how students' participation in Project EcoTower relates to their academic performance in Earth and Space Science.

Ethical Considerations

The researcher adhered to the principles of ethics in educational research while conducting the study. All respondents participated voluntarily. They were informed of the goal, objectives, process, and results of the study and were told that they were entitled to withdraw from the research at any moment without penalty. Informed consent was obtained in writing from every respondent who participated in the survey and interview. Where the participant was a minor, written permission was obtained from the parents or guardians. Confidentiality and anonymity were of great importance: participants were identified in the written surveys and interviews only through anonymous codes. The information collected is kept confidential and was used solely for the purposes of the study.

The researcher further ensured compliance with the provisions of the Data Privacy Act of 2012 (Republic Act No. 10173) by securely protecting research data and storing it in password-protected files accessible only to the researcher and the research adviser. All collected data were retained only for the duration necessary to complete the study and were to be properly disposed of after its completion, in accordance with institutional policies and ethical research standards.

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RESULTS AND DISCUSSION

This section presents and discusses the data gathered on students' involvement in Project EcoTower, their academic performance, and the relationship between these two variables, following the order of the statement of the problem.

Academic Performance of the Respondents in General Science (Earth and Space Science) During the Fourth Quarter

The academic performance of the 132 respondents, based on their fourth-quarter grades in Grade 11 Earth and Space Science, is shown in Table 4.

Table 4. Academic Performance of Students in Earth and Space Science

Level of Performance	Frequency	Percentage (%)
Outstanding	99	75.00
Very Satisfactory	20	15.20
Satisfactory	11	8.30
Fairly Satisfactory	2	1.50
Total	**132**	**100.00**

As shown in Table 4, of the 132 students, 99 (75.00%) obtained Outstanding ratings, followed by 20 students (15.20%) with Very Satisfactory performance, 11 students (8.30%) with Satisfactory performance, and only 2 students (1.50%) with Fairly Satisfactory ratings. Together, 90.20% of the students were in the Outstanding and Very Satisfactory categories, which indicates that the students performed well in the fourth quarter. The students obtained a mean fourth-quarter grade of 92.00.

Level of Students' Involvement in Project EcoTower

Learning Experiences

Table 5. Level of Learning Experiences of the Students

Indicators	Mean	SD	Verbal Description	Interpretation
1. I gained a better understanding of Earth and Space Science concepts through Project EcoTower.	4.46	0.07	Agree	Very high
2. I was able to relate the lessons in Earth and Space Science to real-life environmental situations through the project.	4.57	0.62	Strongly Agree	Very high
3. I found learning more meaningful after participating in Project EcoTower.	4.54	0.66	Strongly Agree	Very high
4. I became more interested in learning about environmental conservation through the project.	4.42	0.67	Agree	Very high
5. I appreciated the importance of protecting Earth's resources after participating in Project EcoTower.	4.62	0.59	Strongly Agree	Very high

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Indicators	Mean	SD	Verbal Description	Interpretation
Composite Mean	**4.52**		**Strongly Agree**	**Very high**

Note. Interpretation scale: 4.21–5.00 = Very high; 3.41–4.20 = High; 2.61–3.40 = Moderate; 1.81–2.60 = Low; 1.00–1.80 = Very low.

The composite mean of 4.52 shows a very high level of learning experiences among the student respondents as a result of Project EcoTower, particularly in their understanding and appreciation of Earth and Space Science. According to Table 5, the highest mean score was 4.62, indicating that respondents strongly appreciated the importance of protecting Earth's resources as a result of their experience in Project EcoTower. This means that the student respondents were able to appreciate the importance of protecting the Earth. Khodaeifaal (2017), in a study of how student engagement influences students' appreciation of learning and their success, found that student engagement plays a significant role in helping students achieve learning experiences and outcomes.

The lowest mean score, 4.42, was for students' growing interest in learning about environmental conservation through the project. Although the lowest, this mean is still interpreted as very high, indicating a positive effect of the students' experience in Project EcoTower on their interest in Earth science. According to Chen (2024), interest is of great significance to the development of an individual's learning activities; it is a driving force that stimulates learning motivation and promotes learning and development. This implies that interest is key to achieving positive learning outcomes and that, since Project EcoTower can ignite learners' interest, excellent academic performance in Earth science is likely to follow. The composite mean of 4.52 means that the level of learning experience in Project EcoTower is very high, which indicates that the project has had a positive influence on academic performance in Earth science.

Skills Development

Table 6. Level of Skills Development of the Students

Indicators	Mean	SD	Verbal Description	Interpretation
1. I improved my problem-solving skills while participating in Project EcoTower.	4.16	0.675	Agree	High
2. I enhanced my critical thinking skills by addressing environmental issues through the project.	4.39	0.674	Agree	Very high
3. I developed my creativity by utilizing recyclable materials during the project.	4.44	0.68	Agree	Very high
4. I improved my teamwork skills while working on Project EcoTower.	4.52	0.636	Strongly Agree	Very high
5. I strengthened my communication skills by sharing ideas with my classmates during the project.	4.46	0.681	Agree	Very high
Composite Mean	**4.39**		**Agree**	**Very high**

Note. Interpretation scale: 4.21–5.00 = Very high; 3.41–4.20 = High; 2.61–3.40 = Moderate; 1.81–2.60 = Low; 1.00–1.80 = Very low.

The students demonstrated a very high level of skills development, with a composite mean of 4.39, indicating that the project helped improve their problem-solving, critical thinking, creativity, teamwork, and communication skills. Because the project was collaborative work, it heightened the collaborative skills of the students as they

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engaged in activities from the planning of the project through its implementation. This is reflected in the highest mean score, 4.52 (Very High), for improved teamwork skills while working on Project EcoTower.

Meanwhile, students identified specific challenges that they faced before and during the project, which were resolved only through understanding one another and asking each other for help. Although the mean for problem-solving skills was the lowest (4.16, interpreted as High), students still saw improvement in these skills, which were complemented by the teamwork skills they learned in collaborating to solve problems. This is consistent with the study of Reutotar (2023), who found that hands-on environmental projects using recycled materials significantly increase student participation and environmental responsibility, showing that Project EcoTower can be an avenue for collaborative work that heightens learners' skills.

Behavioral Changes

Table 7. Level of Behavioral Changes Among the Students

Indicators	Mean	SD	Verbal Description	Interpretation
1. I practice proper waste segregation more consistently after participating in Project EcoTower.	4.36	0.594	Agree	Very high
2. I have become more responsible about reducing my plastic use.	4.41	0.605	Agree	Very high
3. I regularly practice recycling at home.	4.23	0.675	Agree	Very high
4. I encourage my family, friends, or classmates to participate in environmental conservation activities.	4.20	0.739	Agree	High
5. I demonstrate greater concern for the environment in my daily actions after participating in the project.	4.36	0.689	Agree	Very high
Composite Mean	**4.31**		**Agree**	**Very high**

Note. Interpretation scale: 4.21–5.00 = Very high; 3.41–4.20 = High; 2.61–3.40 = Moderate; 1.81–2.60 = Low; 1.00–1.80 = Very low.

The students showed a very high level of positive behavioral changes, with a composite mean of 4.31, particularly in waste segregation, recycling, reducing plastic use, and environmental responsibility. Table 7 shows that students who participated in Project EcoTower were effectively motivated to be more responsible in their plastic use, with a mean of 4.41. On the other hand, with a mean of 4.20, students were less likely to encourage their families and friends to engage in environmental conservation; even though this is the lowest recorded mean, it is still interpreted as High.

This is consistent with the findings of Reyes and Madrigal (2020), who found that practical, low-cost environmental interventions improve students' engagement in sustainability programs, especially in schools with limited resources. Such initiatives give students tangible outcomes of their recycling efforts, making environmental education more impactful and meaningful. Additionally, the high level of positive behavioral change is aligned with Tsai and Tan (2022), who emphasized that contextualized environmental learning increases student engagement and participation by connecting abstract concepts to familiar community problems.

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Summary of Students' Involvement

Table 8. Summary of the Level of Students' Involvement in Project EcoTower

Indicators	Composite Mean	Verbal Description	Interpretation
A. Learning Experiences	4.52	Strongly Agree	Very high
B. Skills Development	4.39	Agree	Very high
C. Behavioral Changes	4.31	Agree	Very high
Grand Mean	**4.41**	**Agree**	**Very high**

Note. Interpretation scale: 4.21–5.00 = Very high; 3.41–4.20 = High; 2.61–3.40 = Moderate; 1.81–2.60 = Low; 1.00–1.80 = Very low.

The overall level of students' involvement in Project EcoTower was very high, as indicated by the grand mean of 4.41, with the highest rating in learning experiences (4.52), followed by skills development (4.39) and behavioral changes (4.31). The students generally agreed that their participation in the project provided meaningful learning experiences, contributed to skills development, and encouraged positive behavioral changes. According to Reutotar (2023), environmental activities, even when low-cost, may provide students with meaningful engagement and thereby opportunities for learning and development toward environmental conservation and action. Table 8 shows that students who participated in Project EcoTower had a high level of involvement, and their participation directed them toward positive change in learning, skills, and behavior on environmental initiatives.

Environmental Awareness Skills Developed Through Involvement in the Project

Table 9. Environmental Awareness Skills of Students

Indicators	Mean	SD	Verbal Description	Interpretation
1. I can identify environmental issues in my community that require immediate attention.	4.30	0.641	Agree	Very highly aware
2. I can distinguish environmentally responsible practices from harmful ones in everyday situations.	4.32	0.597	Agree	Very highly aware
3. I can suggest practical ways to reduce waste and conserve natural resources.	4.45	0.558	Agree	Very highly aware
4. I can make informed decisions that help protect the environment in my daily life.	4.33	0.601	Agree	Very highly aware
5. I actively participate in activities that promote environmental protection and sustainability.	4.19	0.732	Agree	Highly aware
Composite Mean	**4.32**		**Agree**	**Very highly aware**

Note. Interpretation scale: 4.21–5.00 = Very highly aware; 3.41–4.20 = Highly aware; 2.61–3.40 = Moderately aware; 1.81–2.60 = Slightly aware; 1.00–1.80 = Not aware.

The students demonstrated a very high level of environmental awareness skills, with a composite mean of 4.32, indicating their ability to recognize environmental issues and practice responsible actions toward environmental protection. Table 9 shows that students were very highly aware of how to suggest practical ways to reduce waste, which shows how learning experiences based on theory can be translated into practice through participation in Project EcoTower. Although the lowest mean was 4.19, students still showed a high level of awareness of how to participate actively in activities that promote environmental protection and sustainability. This shows the

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importance of the project: even at the grassroots level, initiatives like this can provide students with meaningful learning experiences. Through students' engagement in the activity, Project EcoTower proved to be an effective advocacy tool for raising awareness of environmental action among students.

This supports the findings of Magno (2021), who explained that contextualized instruction enhances students' comprehension of environmental issues by relating lessons to their daily experiences, as students also applied the theories from the lessons in their daily lives. It also aligns with the findings of Reyes and Madrigal (2020), which emphasize that student involvement in waste management programs leads to improved environmental practices and greater behavioral consistency. When students are given active roles, they are more likely to internalize environmental values and apply them in daily life.

Relationship Between Students' Involvement in Project EcoTower and Academic Performance

Table 10. Spearman's Rho Correlation Between Fourth-Quarter Grade and Involvement in Project EcoTower

Variables	Spearman's rho	df	p-value
Fourth-quarter grade and involvement in Project EcoTower	0.254	130	0.005

Note. $p < .05$, **$p < .01$,** $p < .001$.

The findings revealed a weak but statistically significant positive relationship between students' involvement in Project EcoTower and their academic performance in General Science (Earth and Space Science). The students obtained a mean fourth-quarter grade of 92.00, with 75.00% classified as Outstanding, while their involvement in Project EcoTower was generally favorable, particularly in learning experiences (composite mean = 4.52), skills development (4.39), and behavioral changes (4.31). The Spearman's rho analysis yielded a correlation coefficient of $\rho = 0.254$ with a *p*-value of 0.005, indicating a significant weak positive relationship between the two variables. Thus, as students' involvement in Project EcoTower increased, their academic performance tended to increase as well. However, the weak strength of the relationship suggests that students' academic performance is associated with, but not solely determined by, their involvement in the project. Project EcoTower may therefore serve as a meaningful supplementary learning experience that supports science learning and academic achievement.

The overall findings on the relationship between students' involvement and their academic performance coincide with the previously cited studies of Reutotar (2023), Magno (2021), and Reyes and Madrigal (2020). The collective synthesis of their findings is aligned with the findings of this study, which show that the significant positive relationship between students' involvement and academic performance is attributable to Project EcoTower. The project not only improved academic standing but also made learners more participative and responsive to the needs related to the environment and climate action.

Challenges Encountered by Students While Participating in the Project

Table 11. Challenges Encountered by the Students

Rank	Indicator	Frequency (SA and A)	Percentage
1st	I needed additional guidance from my teacher during the project's implementation.	79	59.85%
2nd	I experienced difficulty constructing the EcoTower.	74	56.06%
3rd	I found it difficult to balance participation in Project EcoTower with my other school-related responsibilities.	73	55.30%
4th	I had difficulty obtaining recyclable materials needed for Project EcoTower.	71	53.79%

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Rank	Indicator	Frequency (SA and A)	Percentage
5th	I had limited time to complete the project requirements.	66	50.00%

Note. SA = Strongly Agree; A = Agree; *n* = 132.

The challenges faced by students in undertaking Project EcoTower are shown in Table 11. The first-ranked challenge was the need for more assistance from the teacher, experienced by 79 students (59.85%). The second was difficulty in constructing the EcoTower, reported by 74 students (56.06%). Third was difficulty in balancing involvement in the project with other schoolwork, reported by 73 students (55.30%). The fourth was trouble obtaining recyclable materials, reported by 71 students (53.79%), and the fifth was limited time to finish the project, reported by 66 students (50.00%).

These results demonstrate that students' challenges were mostly associated with technical difficulty and the need for capable instruction; it is therefore important to provide clear instructions, proper supervision, and ongoing assistance for the successful implementation of environmental projects in the future. According to Bajracharya and Maskey (2016), social and institutional support systems play a pivotal role in shaping environmental behavior, and active community participation in environmental programs encourages students to develop and sustain environmentally responsible practices.

Qualitative Results and Discussion

In this study, the qualitative research design was used as part of the mixed-methods approach, and the interview responses on Project EcoTower were analyzed using thematic analysis according to Mortensen's (2020) six-stage approach. The analysis was performed separately for three areas: learning experiences, skills development, and behavioral changes. A summary of the themes, subthemes, and codes is presented in Appendix B. For learning experiences, three themes emerged: Learning Through Practical Application; Awareness of Plastic Waste and Environmental Protection; and Collaborative Learning and Social Participation.

Learning Through Practical Application

This theme comprised responses showing how learners combined information learned in the classroom with hands-on experiences and understood what could be done with waste materials. It produced two subthemes: connecting classroom lessons with actual experience, and learning resource conservation through recycling and reuse. This theme was related to Competency 5, in which students describe the distinctive properties and local availability of earth materials, including rocks, minerals, and soils, and how they are harnessed to support human activities and industries.

Connecting classroom lessons with actual experience. Participants mentioned Project EcoTower as an activity that enabled them to use information learned in class in real practice, demonstrating that practical implementation made the lessons more substantive and applicable to real situations (Figure 2). Participant 2 pointed out that involvement in the project helped him understand Earth and Space Science better because the concepts learned in class were applied in real life. Likewise, Participant 4 indicated that Project EcoTower provided the opportunity to practice the knowledge obtained during classwork through practical activities. Finally, Participant 12 stated that being part of Project EcoTower gave him a deeper understanding of Earth and Space Science as taught in the classroom, allowing him to use the knowledge learned during project implementation.

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Figure 2. Lessons learned in class applied in real practice



According to the learners, the project let them work on some aspects of what they had learned outside the classroom, which is consistent with the theory of practical learning. The participants reported that working on Project EcoTower made it possible to link their Earth and Space Science course with real-life practices. Instead of only listening to lectures or studying reading materials about environmental practices, participants had the opportunity to put theoretical knowledge into practice while creating the EcoTower.

Learning resource conservation through recycling and reuse. Learners associated their experience with a practical understanding of recycling, reuse, and resource conservation. The recurring idea was that materials commonly discarded can be transformed into useful objects (Figure 3). According to Participant 3, the project provided an understanding of the relevance of minimizing waste and reusing materials instead of throwing them away. Likewise, Participant 5 indicated that, through the activity, individuals realized that the things they usually throw away are still useful in some way. Lastly, Participant 11 pointed out the knowledge gained about what can be done with plastic bottles and how these items can be recycled and turned into something functional.

Figure 3. Recycling and reuse of materials



Participants discussed how their perceptions of discarded materials had changed, especially regarding their potential to be transformed into useful items. According to their comments, Project EcoTower offered a chance to link Earth and Space Science class discussions with a practical exercise. Participants talked about using what they had learned while building the EcoTower, as opposed to learning environmental concepts only through lectures or written materials. According to their reports, the hands-on exercise made the lessons easier to comprehend and more applicable to actual circumstances.

Awareness of Plastic Waste and Environmental Protection

This theme captured participants' descriptions of recognizing the amount of plastic waste generated and understanding the environmental value of reusing materials. In line with this, Competency 2 was taken into

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consideration, which describes how the greenhouse effect regulates Earth's temperature, making it suitable for life.

Recognizing the amount and impact of plastic waste. Collecting bottles made the volume of discarded plastic more visible to learners (Figure 4). According to Participant 5, when they began collecting and using plastic bottles, they became aware of the difficulty of accumulating plastic waste. Similarly, Participant 10 expressed astonishment at the amount of waste they collected each day and stated that she was shocked by the amount of waste collected over a relatively short period. These responses suggest that collecting plastic bottles made the presence and volume of plastic waste more noticeable. In general, the collection experience gave participants an opportunity to understand the connection between one common behavior, getting rid of plastic bottles, and the larger issue of waste production. Waste turned from an abstract environmental problem into a concrete and defined experience.

Figure 4. Awareness of plastic waste



Recognizing the environmental value of discarded materials. Learners described recognizing that materials normally considered waste could still serve a useful purpose. Participant 3 highlighted how the project illustrated the possibility of appreciating the reuse of items by showing how junk could be rendered useful. Participant 5 also talked about the idea that even simple recycling activities could help protect the environment and so contribute to the preservation of nature. At the same time, Participant 12 said that even things that are usually discarded could still be used again. These responses indicate that participants frequently realized that discarded materials can largely be repurposed for useful and environmentally beneficial purposes. This suggests that the project made participants revise their views on waste and usefulness. Instead of perceiving plastic bottles only as waste, participants began to see their potential as parts of a planting device. Hence, the EcoTower served as a practical demonstration of how an ecological activity may be transformed into an example of reuse.

Collaborative Learning and Social Participation

This theme highlighted learning experiences fostered through collaboration, effective communication, and the sharing of ideas with classmates. It emphasized Competency 7, which uses evidence from secondary resources to describe how human activities have contributed to the modification of landforms and bodies of water of the Philippines (Figure 5).

Learning through teamwork and shared participation. The project was a collective activity that required contributions and cooperation from group members. This subtheme was based on Participant 9's response that everyone was involved: they brought materials, paint, and brushes, and every day they maintained progress and good communication with one another. Moreover, Participant 4 mentioned that they were not just saving the Earth; they were also making friends, helping each other, and working together. Lastly, Participant 10 said it was enjoyable because they could see that everyone was willing to help and participate in the project.

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Figure 5. Collaborative effort and social participation



Sharing ideas and learning from classmates. Participant 16 emphasized that Project EcoTower made the learning experience more enjoyable and meaningful because it involved actual activities and collaboration with classmates rather than simply listening to classroom discussion. The participant further explained that the project provided an opportunity to experience the lessons firsthand, making topics about Earth's resources and climate change easier to understand through practical application. Also, Participant 17 mentioned that Project EcoTower made learning more meaningful because they were not only listening to discussions but also doing an actual activity, which was more enjoyable because they worked with classmates and shared ideas. Hence, the lesson about the characteristics of the Earth became more interesting.

According to the responses, the participants perceived the EcoTower as a collaborative project resulting from the contributions of many members of the group. The responses indicate that the learning experience was broader than the making of the physical object: participants had to face the challenges of cooperating in organizing the work, gathering materials, and achieving a common goal.

The participants' feedback revealed that, in the students' opinion, Project EcoTower was characterized by "learning by doing." Three main aspects were consistently found in the participants' replies: putting theory into practice while making the structure, realizing the importance of recycling, and cooperating with peers in a joint activity. The findings confirm that students perceived the project as engaging and as facilitating learning. Overall, the responses about learning experience depict Project EcoTower as an activity that is practical, socially interactive, and focused on the environment. Participants reported putting classroom concepts into practice, seeing the value of recyclable materials, becoming more conscious of plastic waste, and finding the experience both engaging and meaningful. Taken together, these accounts indicate that learners saw the project as linking subject learning to a tangible environmental task.

These themes reflect the link between hands-on environmental programs and engagement through informal social interaction, freedom of personal choice, and meaningful physical activity. Research synthesizing studies on environmental education programming found that these three factors were critical to children's ability to make meaning from environmental experiences: when students had opportunities to explore, interact with peers spontaneously, and exercise agency over their learning tasks, their engagement and depth of environmental understanding increased substantially (Zalla & Yates, 2020).

Under skills development, three themes were identified: Creativity and Resourcefulness in Design; Practical Problem-Solving and Design Adjustment; and Communication and Collaborative Work. These themes show the learning of skills among students who participated in the project and are broken down further into subthemes discussed below (Figure 6).

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Figure 6. Resourcefulness, practical problem-solving, and communication



Creativity and Resourcefulness in Design

Participants reported using artistic ideas to make the EcoTower and its components more distinctive. This theme aligned with Competency 11, which proposes ways to adapt to and mitigate the impacts of climate change on local biodiversity.

Developing and expressing creative design ideas. As stated by Participant 1, the project helped improve their creativity because they could express their ideas in colors, designs, and artistic styles. Participant 3 agreed, noting that they were able to create new ideas and designs that made the EcoTower unique. Finally, Participant 11 mentioned that the activity allowed students to apply their creativity in creating different designs and expressing their potential. These responses mean that creativity was applied to a real outcome and was not just a theoretical exercise. The findings suggest that the project provided a context for expressing and applying creative ideas. However, the responses do not establish the extent of improvement in creativity, nor do they provide a standardized measure of participants' design proficiency.

Using available materials resourcefully. The project required participants to consider how available or discarded materials could be used to meet design requirements. Participant 2 emphasized that the use of recyclable materials encouraged resourcefulness by requiring learners to think of ways to transform discarded materials into useful objects. Likewise, Participant 7 reiterated the opportunity to foster design skills and create meaningful products out of materials considered useless by others. Finally, Participant 10 pointed out that the project promoted resource conservation because it encouraged the use of locally available materials at home rather than the purchase of new ones. These accounts suggest that the EcoTower task required participants to consider alternative uses for materials and to make practical decisions based on what was available. Resourcefulness emerged as a response to the constraints and possibilities of the project: learners needed to work with existing resources instead of assuming that new materials were always necessary. This supports the interpretation that the activity provided opportunities to practice resourcefulness, although the extent of individual skill development would require additional assessment.

Practical Problem-Solving and Design Adjustment

Under this theme, two subthemes support the claim that students learned practical problem-solving skills. Competency 11, which proposes ways to adapt to and mitigate the impacts of climate change on local biodiversity, was also highlighted here.

Identifying construction problems and finding solutions. Participants described encountering practical problems and discussing or testing possible solutions. This supports reports of problem-solving practice, not a standardized measurement of problem-solving proficiency. Participant 4 mentioned that the group faced challenges in combining different ideas about the design and layout of the project and pointed out how difficult it was to build the tower with ordinary wooden materials; after the group discussed and voted, it decided on the

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design of the tower. Participant 4 noted another difficulty: the EcoTower's stability; according to the participant, the group debated the issue and figured out a solution. Lastly, Participant 10 observed that one challenge was the EcoTower's lack of stability during construction: the tower tilted because of the light base, so the group decided to add some cement and more soil to strengthen the foundation. These answers show a process of identifying a problem, thinking about its cause, and making an adjustment. Participants were not simply following a pre-planned pattern, and at least some of them described how they reacted to unexpected obstacles that arose during the project.

Seeking information and evaluating design options. Some participants described seeking information to guide decisions about design and construction. The idea of constructing the EcoTower led Participant 6 to carry out additional research on possible designs and ways of growing plants in the area. Participant 7 pointed out that, regardless of the unusual construction used in creating the EcoTower, it is equally important to create holes in the materials and to attach or hang the elements properly. The responses indicate that the project gave rise to independent searching for information and to the development of research abilities as well as problem-solving skills in the process of completing the project. Participants occasionally dealt with uncertainty by consulting others or looking for information, which shows an attempt to make better-informed design decisions instead of depending solely on initial ideas. In essence, the project appears to provide opportunities for informal research and for comparing approaches.

The themes suggest that the EcoTower offers opportunities to use creativity, resourcefulness, and problem-solving, as well as to develop communication and coordination strategies and perform hands-on construction work. Participants often related those abilities to project requirements such as modifying recyclable material, stabilizing the structure, redesigning, and coordinating contributions. By comparison, Mansfield (2023) stated that hands-on science teaching in middle school settings has a similar effect and produces a long-term influence on students, improving their conceptual knowledge and engagement.

Lastly, under behavioral changes, two major themes were identified: Adoption of Waste-Reduction Practices and Internalization of Environmental Responsibility. The responses describe four related patterns: reuse and waste reduction, personal environmental responsibility, encouragement of others, and reported application of practices at home or in later school projects. Competency 10, which concerns developing family preparedness plans and community-based disaster risk reduction and management plans to prepare for, respond to, and recover from natural hazards, was initially an additional highlight of this code.

Adoption of Waste-Reduction Practices

Under this theme, a subtheme was identified: reusing and recycling plastic materials (Figure 7). Participants reported preferring reuse and recycling over immediate disposal or the purchase of new materials. Participant 1 mentioned that the project motivated students to act and to recycle waste by reusing materials that can still work and be useful. In the same way, Participant 9 stressed that repurposing plastic materials was much better than buying new ones because creativity can give a better appearance and turn them into something more innovative. Such answers show that Project EcoTower boosted proper waste management and made participants aware that reusable materials can replace newly purchased ones.

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Figure 7. Waste reduction practices



Internalization of Environmental Responsibility

Under this theme, two subthemes were supported, showing how students perceive the importance of collective action and not merely individual action.

Recognizing personal responsibility. Participants framed environmental protection as a responsibility they could personally contribute to, rather than a task belonging only to institutions or adults. Participant 2 said that, as a student, environmental protection was not only the responsibility of the school or other people; there are simple things that can be done every day to help protect the environment. Participant 5 likewise mentioned becoming more responsible after realizing that protecting the environment is not only the responsibility of the school or other people. The responses suggest that environmental protection was increasingly described as a personal responsibility rather than an obligation belonging only to schools, institutions, or others, and that participants recognized a role for their own actions. Rather than viewing environmental care as something beyond their control, they described practical actions they could take in their everyday surroundings. This suggests a reported change in how they understood their individual responsibility. However, the responses demonstrate expressed awareness and perceived responsibility, not necessarily sustained action or a measurable change in environmental attitudes.

Valuing small and consistent environmental actions. Participants expressed the belief that small actions can contribute to environmental protection. Participant 1 shared that, because of the EcoTower project, they realized that even small actions, such as recycling and taking care of plants, can help protect the environment. This was supported by Participant 6, who mentioned that care for nature lies not in grand things but in simple practices carried out consistently every day. These accounts indicate that participants understood environmental responsibility as something that can be expressed through ordinary, accessible activities rather than only through large-scale initiatives. This perspective may help make environmental participation seem achievable in everyday life, and the findings support the interpretation that participants valued small environmental actions.

The reported behavioral changes suggest that the students associate the project with a better understanding of their active role as environmental ambassadors of the 3Rs, proper waste disposal, and other responsibilities for climate action. One notable pattern is that some participants described specific actions or intentions related to their day-to-day routines, which suggests that the project was relevant to changes in their environmental behavior and perspectives. The themes align with Balundė et al. (2020), who traced the psychological pathway from adolescent biospheric values through environmental self-identity and personal norms to a wide range of pro-environmental behaviors, offering a theoretical mechanism that explains why school-based sustainability programs may change behavior even when they successfully build knowledge.

Proposed Action Plan to Address the Challenges Encountered by the Students

To address the challenges encountered by the students, the action plan presented in Table 12 is proposed.

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Table 12. Proposed Action Plan

Challenges	Objective	Action	Resources	Expected Outcome
Difficulty obtaining recyclable materials needed for Project EcoTower (*M* = 3.55)	To ensure that students have adequate recyclable materials for the project.	Establish a Recyclable Materials Collection Drive in which students, teachers, and parents collect and donate plastic bottles and other recyclable materials before project implementation.	Collection boxes, recyclable materials, posters, sacks, storage area	Students will have sufficient and readily available materials to complete their EcoTower.
Limited time to complete the project requirements (*M* = 3.48)	To provide students with sufficient time to accomplish the project requirements.	Provide a clear project timeline and schedule, including deadlines for material collection, construction, planting, and submission. Allow students to work on the project during designated class or activity periods.	Project calendar, schedule, task checklist	Students will manage their time better and complete project requirements within the given period.
Difficulty in constructing the EcoTower (*M* = 3.59)	To improve students' skills and confidence in constructing the EcoTower.	Conduct a hands-on demonstration and step-by-step workshop before construction. Provide simple instructions and allow students to work in small groups.	Sample EcoTower, instructional guide, tools, recyclable materials	Students will develop better construction skills and experience fewer difficulties during project implementation.
Need for additional guidance from the teacher (*M* = 3.67)	To provide adequate support and guidance throughout project implementation.	Conduct regular teacher consultations and monitoring sessions. Provide demonstrations, feedback, and troubleshooting assistance at each stage of the project.	Teacher guide, monitoring checklist, instructional materials	Students will receive timely assistance and become more confident in completing the project.
Difficulty balancing participation in Project EcoTower with other school-related responsibilities (*M* = 3.46)	To help students manage their project responsibilities alongside their academic tasks.	Assign specific roles and manageable tasks to group members and coordinate project deadlines with other subject requirements.	Task assignment sheet, project schedule, group monitoring form	Students will be able to balance their project responsibilities with other school requirements more effectively.

The study by Kokotsaki et al. (2016) confirms the conclusion of the present study that effective guidance from teachers, scaffolding of instructions, collaboration, and support are necessary for successful project-based learning. Teachers play a crucial role in organizing students' participation in project-based learning. The present findings therefore suggest that students require more guidance from their teachers while performing the technical tasks necessary for building the EcoTower. Additionally, the study by Condliffe et al. (2017) stressed that the success of project-based learning depends on proper planning, the presence of important resources, clear objectives, and constant feedback. These factors naturally address the problems of material availability, scheduling, and completion of tasks. Therefore, the recommendations of this project, such as organizing recyclable-materials collection activities and keeping a clear schedule of activities, are based on effective project-based learning principles.

Implications of the Findings for Science Education

1. **Project-based learning can be strengthened in Senior High School science.** The significant positive relationship suggests that authentic activities such as Project EcoTower can be incorporated

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into Earth and Space Science instruction to provide students with opportunities to apply scientific concepts in practical situations. The students reported particularly high learning experiences, with a composite mean of 4.52, including relating Earth and Space Science lessons to real-life environmental situations.

2. **Environmental projects can support meaningful and contextualized science learning.** The findings imply that science instruction may become more meaningful when lessons are connected to real environmental concerns. Project EcoTower allowed students to appreciate the importance of protecting Earth's resources and to relate classroom concepts to environmental situations.
3. **Project-based activities can develop essential 21st-century skills.** The data show that Project EcoTower helped students feel that they gained problem-solving, critical thinking, creativity, teamwork, and communication skills, with an average of 4.39 (Agree). It can therefore be inferred that, for Senior High School science activities to be effective, they should facilitate collaboration and problem-solving instead of relying on traditional classroom activities alone.
4. **Science education can promote positive environmental behaviors.** The data on behavioral changes indicated that students reported an average of 4.31 (Agree), confirming that they began to pay more attention to waste sorting, reduced plastic use, increased plastic recycling, and showed more concern for the environment. It can therefore be concluded that Senior High School science can combine scientific knowledge with environmental projects for the purpose of responsible environmental behavior.
5. **Adequate teacher support, resources, and time should accompany project-based learning.** The data show difficulties in conducting similar science projects that require consideration. Students indicated that they needed more teacher support (M = 3.67), found it difficult to build the EcoTower (M = 3.59), and had difficulty collecting recyclable materials (M = 3.55). Teachers should therefore give accurate guidelines and demonstrations, provide appropriate materials and timeframes, and supervise project implementation regularly.

CONCLUSIONS AND RECOMMENDATIONS

Summary of Findings

This study examined students' involvement in Project EcoTower: Plastic to Plants and its relationship with their academic performance in General Science, particularly in Earth and Space Science. It investigated students' learning experiences, skills development, and behavioral changes toward improving their environmental awareness. The study employed both quantitative and qualitative research methods. The major findings are as follows:

1. Students demonstrated a high academic level in the fourth-quarter grading period and showed outstanding performance.
2. The mean value of students' participation in Project EcoTower was 4.41, interpreted as Very High participation. **Learning experiences** scored 4.52, and the qualitative analysis confirmed the quantitative data. Several patterns were connected with learning through real-life application, gaining an understanding of plastic pollution and environmental protection, collaborating with others, and finding the experience satisfying. Students claimed that they used knowledge gained in class, identified the possible usefulness of items considered waste, collaborated with peers, and enjoyed the process. **Skills development** ranked second in level of participation, with a mean of 4.39. Participants mentioned creativity, resourcefulness, critical thinking, communication, teamwork, organization of tasks, and technical construction skills as areas of skills developed. The project required using different resources, making design decisions, facing the challenges of building, and completing everything on time. **Behavioral changes** showed a lower level of participation but were still very high, with a mean of 4.31. In the thematic analysis, participants showed awareness of recycling and reusing, proper waste disposal, environmental responsibility, and encouraging others to care for the environment, as well as being environmentally active at home

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and at school. The sustainability of the reported changes was not established, but students regarded the project as related to their everyday lives.

3. **Environmental awareness skills.** Overall, students exhibited a Very High level of awareness, with an overall mean of 4.32 for the composite variable. The highest mean was for the ability to suggest practical ways to minimize waste and conserve the environment (4.45), followed by the ability to make informed decisions that help protect the environment in daily life (4.33), the ability to distinguish harmful from environmentally responsible practices (4.32), and the ability to identify pressing environmental issues requiring immediate attention (4.30).
4. **Relationship between students' involvement and academic performance.** Based on Spearman's rank-order correlation, a weak yet statistically significant positive relationship was identified between student participation in Project EcoTower and academic performance in General Science, specifically Earth and Space Science ($\rho = 0.254$, $p = 0.005$). Because the p-value fell below the 0.05 threshold, the null hypothesis of no significant association was rejected under the study's prescribed methods and assumptions. The positive coefficient indicates that increased involvement in the project generally corresponded to higher academic achievement.
5. **Challenges encountered by the students.** The students faced different problems in the course of their participation in Project EcoTower. The most frequent was the need for more teacher support (79 students, 59.85%), followed by difficulties in building the EcoTower (74 students, 56.06%), difficulty in combining the project with other school tasks (73 students, 55.30%), difficulty in obtaining recyclable materials (71 students, 53.79%), and, lastly, time limits (66 students, 50.00%). In general, the challenges were mainly related to the need for teacher guidance in supervising the project, problems with construction, and time management.

Conclusions

Based on the findings of the study, the following conclusions were drawn:

1. Students demonstrated generally high academic performance in General Science, specifically Earth and Space Science. The fourth-quarter mean grade of 92.00, along with 75% of students in the Outstanding category, reflects a favorable academic standing for the evaluation period. Nevertheless, these findings do not conclusively establish that Project EcoTower alone was responsible for the students' academic achievement.
2. Students showed a high degree of involvement in Project EcoTower. Overall perceptions were positive, as evident from the grand mean of 4.41. The highest score was achieved by learning experiences, followed by skills development and behavioral changes. This indicates that the respondents considered the project a worthwhile co-curricular activity that enables them to apply theoretical knowledge to practical learning, teamwork, and environmental activities.
3. Students reported positive environmental habits and mindsets in connection with their participation. Self-evaluations were quite positive, with mean scores of 4.31 for behavioral changes and 4.32 for environmental awareness skills. Qualitative data also emphasized behaviors of separating waste, recycling, being responsible, and spreading responsible behavior. Nevertheless, self-reports alone cannot confirm sustained behavioral change.
4. Student engagement in Project EcoTower showed a weak yet statistically significant positive correlation with academic performance ($\rho = 0.254$, $p = 0.005$); participation therefore appears to have some association with academic performance. Because of the low degree of correlation, it cannot be concluded that participation is a major contributing factor to academic performance, and it is not possible to claim a direct causal connection between participation and academic achievement.
5. Implementation challenges emerged during Project EcoTower that warrant attention in subsequent iterations. The key issues raised by participants were limitations in materials, difficulties in construction, and the need for improved teacher guidance. These issues indicate that proper training, logistical support, technical assistance, and time management are critical for optimizing future environmental undertakings.

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Recommendations

Based on the findings and conclusions, the following recommendations are presented for consideration:

1. **For science teachers.** Science teachers are encouraged to apply hands-on environmental work, such as Project EcoTower, to lessons whose aims are closely connected with the environmental aspects of the Earth and Space Science curriculum. Teachers should clarify the scientific principles pertinent to the activity, offer guiding questions, and require students to relate their observations to those principles. They are also encouraged to provide step-by-step instructions, explain how to build the EcoTower, and consult with students throughout the process. Because teacher guidance was noted among the biggest hurdles, gradual guidance should be provided at relevant times.
2. **For school administrators.** School administrators are encouraged to support the implementation and enhancement of Project EcoTower by providing appropriate resources, setting aside areas for the processes involved, and giving time for planning, construction, and monitoring. For example, the school may create a system for storing recyclables beforehand. Administrators may also include Project EcoTower in larger school environmental projects or waste management programs, and connect science educators, students, and coordinators of environmental projects.
3. **For project coordinators and implementers.** Schools can enable Project EcoTower to become a permanent educational platform through plant care activities, waste audits, and recycling campaigns. Where possible, collaboration with local government authorities, organizations, and community allies can help obtain required materials, deliver environmental education, and manage waste effectively. Future projects need to use measurable parameters that allow the assessment not only of the levels of students' participation but also of their performance (e.g., plastic utilized, plant survival rate, and waste management practices).
4. **For students.** Students should continue applying the environmental practices learned during Project EcoTower, such as waste separation, recycling, and proper waste disposal. They should be encouraged to introduce these practices to their classmates and families and to participate in various school activities. Students should also keep records of the activities performed using the eco-friendly practices learned as part of the project and engage in planning, making, and monitoring more activities to further develop their communication and cooperation skills.
5. **For the school's environmental and sustainability programs.** The school is encouraged to adopt Project EcoTower as an ongoing environmental education program, with plant care, waste audits, recycling programs, and other environmental activities, and, if required, to establish partnerships with local government authorities and organizations. Program evaluation should include indicators of participation and student achievement that can be observed in practice (e.g., amount of plastic reused, parameters of student performance, and indicators of waste management practices).
6. **For future researchers.** Future research on Project EcoTower should be designed with a methodology that best distinguishes correlation from causation; where possible, pre- and post-testing, longitudinal methods, and control groups can be applied. Researchers are also encouraged to employ validated assessment rubrics, systematic behavioral observations, participant interviews, and longitudinal monitoring to determine whether students sustain the relationships among student engagement, environmental literacy, academic performance, and other external factors that may influence learning outcomes. Lastly, researchers should give particular attention to the operational challenges identified in this study, namely the availability of resources, difficulties in structural construction, and the need for instructional support. Examining these concerns may help develop a practical, efficient, and adaptable implementation framework for environmental education programs in different school settings.

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