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BAYANI TERRIBLE VICENCIO

ENGAGEMENT AND ITS DIMENSIONS AS STUDENT FACTORS OF ACADEMIC PERFORMANCE AND ATTITUDE TOWARDS BIOLOGY IN A GARDEN-BASED LEARNING ENVIRONMENT

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This paper prepared by **BAYANI T. VICENCIO** with the title: **"ENGAGEMENT AND ITS DIMENSIONS AS STUDENT FACTORS OF ACADEMIC PERFORMANCE AND ATTITUDE TOWARDS BIOLOGY IN A GARDEN-BASED LEARNING ENVIRONMENT"** is hereby accepted by the Faculty of Education, U.P. Open University, in partial fulfillment of the requirements for the degree Doctor of Philosophy in Education.

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Biographical Sketch

BAYANI T. VICENCIO was born on May 19, 1982 in Pantay Matanda, Tanauan City, Batangas. He is the youngest son of the late Sofronio M. Vicencio, a retired jail guard, and Benita T. Vicencio, a retired public-school teacher.

He finished his primary education at Pantay Elementary School and his secondary education at Saint Thomas Academy. In 2003, he earned his Bachelor of Science in Biology degree at Batangas State University. He studied and completed his Master's degree in Environment and Natural Resources Management with a major in Coastal Management at the University of the Philippines Open University as a result of his enthusiasm and ardent support for the environment. He is also an active member of the Biology Teachers Association (BIOTA) Philippines and the Philippine Society for the Study of Nature (PSSN) Inc.

He was awarded as the Most Outstanding Public-School Teacher in 2020 by the Rotary Club Tanauan. He also received commendations from the Department of Education for being a module writer, Radio-based Instruction (RBI) script writer and editor and content validator of science modules at elementary level. In May 2021, he was awarded as one of the Outstanding Educators in Creative Science during the 1st Luminary Excellence in Education and Research Awards (LEERA).

At present, Bayani T. Vicencio is a Master Teacher II and Research Coordinator at Pantay Integrated High School- Senior High School Department wherein he indoctrinates science and research subjects such as Earth and Life Science, Physical Science, Practical Research 1, Practical Research 2, and Inquiries, Investigations and Immersions.

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Bayani Terrible Vicencio

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Dedication

To those who believed in me when I didn't believe in myself;

To those who never give up on their dream that they've been chasing almost their life;

To myself, who spent almost ten years of dreaming of becoming a Ph.D. degree holder;

To Inay Bening and Tatay Fren, who instilled in me the virtues of perseverance and commitment. Your heavenly inspiration was felt in every step of this process. At last, your "bunsoluloy" finally made it; and

To all my past, present, and future students, may your inquiring minds lead you forward with confidence, bravery, and grace into the great unknown.

Table of Contents

List of Tables

List of Figures

Abstract

This study investigated learning engagement and its dimensions (i.e., cognitive, behavioral and emotional engagement) as factors influencing students' academic performance and attitude towards biology in a garden-based learning environment. A descriptive-correlational research design was employed to provide a relevant interpretation of the relationship between variables such as respondents' demographic profile, dimensions of engagement in garden-based learning, academic achievement of students and their attitude towards Biology.

The study consisted of seventy (70) Grade -11 students enrolled in a public senior high school of City Schools Division of Tanauan taking up the core subject Earth and Life Science during the first semester of School Year 2020-2021. Over the course of eight weeks, garden-based learning approach was used to teach plant-related topics and students were given the task to complete fourteen (14) garden-based learning activities. Data were collected using expert-validated researcher-made instruments tested for reliability such as the Learning Engagement Survey Questionnaire (LESQ) and Life Science Achievement Test (LSAT) and Students' Perception toward Garden-Based Learning (GBL), in addition to the researcher-developed Garden-based Learning Manual and the adopted instrument on Attitude Towards Biology Survey (ATBS). These three self-report survey questionnaires and the achievement test were all administered at the end of eight weeks of exposing the students to garden-based learning activities. Data obtained were analyzed using both descriptive and correlational tests. The descriptive statistics computed were measures of central tendency, frequency, and percentages. The scores on Life Science Achievement Test obtained by the student were used in analyzing their level

of academic achievement by comparing it to the DepEd standards. On the other hand, Kendall's Tau Rank Correlation and Cramer's V was employed to determine the association between the extent of engagement, profile variables, academic performance, and attitude towards Biology. In addition, qualitative analysis was conducted through focus group interviews, attitude questionnaires, activity reports, reflection journals, and in-depth probing interviews to better understand students' perceptions of garden-based learning.

The study found that GBL, as a teaching strategy, effectively promotes learning engagement and fosters positive attitudes towards Biology among students across age and sex groups. Academic performance of the students was discovered to have a low association towards the extent of learning engagement in garden-based learning. On the other hand, Cognitive, Behavioral and Emotional Engagements have weak positive association towards the students' attitude towards Biology.

Given the demonstrated benefits of garden-based learning, policy makers, curriculum designers and developers should consider incorporating this method into the broader Biology curriculum. Additionally, the curriculum should be designed to allow for personalization of learning experiences, catering to individual students' strengths and requirements.

Chapter I

INTRODUCTION

Background of the Study

The novel Coronavirus (COVID-19) pandemic has affected various sectors worldwide, and education is not an exception. One area that has seen a considerable shift in its dynamics is garden-based learning. This form of pedagogy utilizes gardens as the milieu for student engagement, offering meaningful and relevant curricular and instructional integration in schools. The approach, which is primarily used to enhance academic performance, especially in science, language arts, and math, has also shown promise in promoting motivational engagement, social, moral, and emotional development, strengthening institutional and community bonds, vocational skills development, food literacy, healthy eating habits, and holistic growth of children and youth (Oxford Research Encyclopedia, 2023).

COVID-19 forced many educational institutions to close their physical campuses temporarily or for extended periods. During these closures, schools had to swiftly adapt to distance learning methods to continue providing educational content and engagement to students remotely. While the COVID-19 pandemic presented challenges for hands-on learning during distance learning, garden-based learning offered an opportunity to continue experiential education and engage students in nature-based activities. By incorporating outdoor and hands-on learning experiences, educators could provide valuable learning opportunities and support students' well-being during these challenging times.

In response to the challenges posted by the result of the 2018 Program for International Student Assessment (PISA) conducted by the Organization for Economic Cooperation and Development (OECD), the Philippines is on its way to bringing about reforms in science education curriculum directed towards improving the science achievement of students especially in the basic education level. Filipino students attained an average of 357 points in scientific literature, which was lower than the OECD average of 489 points. Hence, the Philippines ranked second to the lowest in science out of 79 participating countries. This accords with the dismaying performance of the Philippines in the Third International Mathematics and Science Study (TIMSS) and National Achievement Test (NAT). Several reports have documented that Filipino learners consistently perform abysmally in science during the last few decades both in national and international surveys (Gonzales, et al., 2004; DepEd EFA, 2015 as cited by Fetalvero, 2017). In 2003, the country ranked only 43rd out of 46th participating countries in High School II Science. Our country stopped participating in the survey in 2008, perhaps after getting a lackluster performance. On the other hand, the performance of both Grade 6 and Grade 10 learners in NAT suffered a downward trajectory in the last three years, placing them at the "low mastery" descriptive level of the Department of Education (DepEd). The 2018 NAT results showed that the performance of Grade 10 students minimally increased from 44.08 in 2017 to 44.59 in 2018 and way from 53.77 in 2014.

One of the reasons singled out by most researchers why this phenomenon persists is the students' growing negative attitude towards science which consequently compromises their performance and achievement, dissipates their interest, and distorts their worldview of what science should be like (Fetalvero, 2017; UNESCO, 2010). This seriously threatens society's economic prosperity since science and technology forms the backbone of a knowledge-based economy (Osborne, Simon & Collins, 2003). Thus, the development of positive attitudes towards science among students becomes an important and uncontested goal of science education (Ong & Yeo, 2012). Another challenge confronting science educator nowadays is the waning learning engagement of students. Many different studies have analyzed the sources of the problem and these analyses have pointed to a range of interrelated factors such as traditional teaching methods applied by the teacher in presenting the lesson, the abstract nature of the subject, congested curriculum and insufficient hands-on activities provided to the learners.

Numerous studies pointed out that school gardens are ideal settings for experiential learning. A school garden is an innovative teaching tool and strategy that allows educators to incorporate hands-on activities in a diverse interdisciplinary, standards- based lessons (Pounders, 2010). The garden provides the students a dynamic environment in which they can observe, discover, experiment, nurture and learn. It serves as a living laboratory where lessons can be drawn from real-life experiences rather than textbook examples, allowing students to become active participants in the learning process instead of becoming passive receivers of information.

The idea of incorporating the natural outdoors as an integral part of children's educational curriculum is not new to most of us. In fact, several educational philosophers back to the 17^{th} century have promoted the use of gardening to achieve learning objectives and support the mental, emotional, and social development of youth. Thus, for the past 20 years, there has been a resurgence of interest in school garden programs. Although their popularity has waxed and waned over the 200 years since Henry Lincoln Clapp introduced the first school garden in the US by 1811

(Subramanium, 2002), current enthusiasm reflects an appreciation of the potential benefits that can be derived from them. Garden-based learning strategy provides a range of benefits including perceived perceived improvements of academic achievement, promoting healthy eating habits, and increasing students' knowledge and appreciation of the natural world (Draper & Freedman, 2010). The philosophy behind garden-based learning is an amalgamation of the philosophies behind experiential education, ecological literacy, environmental awareness, and agricultural literacy. In other words, it involves teaching children through personal discovery in natural settings, where they can learn ecological principles that govern all life and develop a sense of connection with nature.

Thousands of school gardens exist in the US and are being used as a milieu for integrated curriculum. As garden programs have burgeoned, educators increasingly recognize their potential as a vehicle for promoting school success across the curriculum. Such programs can awaken students to the value of science and sustainability, enhancing their motivation and achievement in school. Principals and teachers are so enthusiastic about garden-based learning because these programs seem to capture students' interest and energize their learning. Qualitative studies consistently report students' delight, enthusiasm, and vigorous participation in gardening activities. These findings are echoed by a small number of quantitative studies suggesting that learning activities organized around the environment result in higher levels of interest and effort. The core features of garden-based learning, which provide contextualized authentic, project-based, hands-on learning activities, are designed to capture students' interest and engagement. In addition, many studies have shown perceived improvements in students' academic performance using garden-based learning. Some of the strongest academic gains appear in the areas of Math and Science.

Results of academic performance and higher test results are not the only benefits of garden-based learning. Research and anecdotal reports from teachers strongly support the value of gardens in creating a positive learning environment. Evidence showed that garden-based activities played an important role in improving the environmental attitude of children. Past research also indicates that children who participated in numerous outdoor activities have more positive environmental attitudes compared to children with fewer outdoor experiences.

While previous research has explored the potential benefits of garden-based learning, such as enhanced academic performance and increased environmental awareness, there is a paucity of research investigating its impact on student engagement and attitude towards specific subjects like Biology. Moreover, the correlation between the extent of engagement in garden-based learning and academic performance in Science has not been thoroughly explored, particularly in the context of the recent shift towards remote learning due to the pandemic. There is also a lack of understanding about the relationship between garden-based learning and learners' attitudes towards Biology, an essential element that could influence their learning outcomes and career decisions (Ortega-Cubero, I. (2020). The present study seeks to address these gaps in the literature by exploring the correlation between the student's engagement specifically in cognitive, behavioral, and emotional dimensions in garden-based learning and academic performance in Science, as well as learners' attitude towards Biology. In addition, association between the learner's socio-demographic profile and level of engagement among different dimensions were investigated as well.

Statement of the Problem

The study aimed to ascertain association of dimensions of learning engagement in garden-based learning with academic performance in Science and attitude towards Biology.

Specifically, it sought answers to the following questions:

1. What is the profile of the student respondents in terms of:

    1.1 age; and

    1.2 sex

2. What is the extent of engagement of the students in garden-based learning in terms of its dimensions such as:

    2.1 cognitive engagement;

    2.2 emotional engagement; and

    2.3 behavioral engagement?

3. What is the level of performance of students based on their achievement score in Life Science taught using the garden-based learning approach?

4. What is the attitude of the students under the garden-based learning environment towards Biology in terms of:

    4.1 importance of Biology;

    4.2 interest in Biology lessons;

    4.3 perceptions of the Biology teacher;

    4.4 keenness to learn Biology;

    4.5 enjoyment of Biology;

    4.6 anxiety towards Biology; and

    4.7 effort in learning Biology?

5. Is there an association between the dimensions of learning engagement in garden-based learning and the profile variables?
6. Is there a correlation between the dimensions of learning engagement in garden-based learning and:
    6.1 academic performance; and
    6.2 attitude towards Biology?
7. What is the perceived impact of garden-based learning on their attitude and behavior towards learning Biology as assessed by the student-respondents?
8. Based on the findings of the study, what framework could be designed to enhance the learning engagement, academic performance, and attitude towards Biology out of the Garden-based Learning activities?

Significance of the Study

The conduct of this study was believed to be beneficial to certain individuals or groups of people in enhancing the thrust of the academe in garden-based learning.

Science Education Supervisors/Specialists: This study held significance for science education supervisors and specialists as it provided insights into how garden-based learning could influence learning engagement and academic performance in Science. The findings could guide these professionals in their roles of supervising science teachers and providing instructional support, particularly in incorporating garden-based learning into science teaching. By understanding the benefits and challenges of this approach, they would be better equipped to guide science teachers and facilitate the effective implementation of garden-based learning in schools.

Curriculum Designers and Developers: For curriculum designers and developers, the study offered a deeper understanding of how garden-based learning could be integrated into the science curriculum. The results of this study provided evidence of the extent of learning engagement and its dimension in garden-based learning and its correlation with academic performance in science, which could be instrumental in the design of innovative, relevant, and engaging science curricula. It might also have highlighted areas where curricula could be adapted to better facilitate garden-based learning experiences.

Science Teachers: Science teachers stood to benefit from this research as it informed their teaching strategies and practices. By understanding the relationship between garden-based learning and students' academic performance and attitude towards Biology, teachers could implement these techniques in their classrooms to enhance student engagement and learning outcomes. Furthermore, it offered teachers innovative methods to make science learning more practical, hands-on, and relevant, thereby potentially improving students' interest and performance in the subject.

Learners: The study held significance for learners as it investigated a learning approach that potentially offered a more engaging, practical, and holistic way to learn science. Depending on the results, learners could benefit from more widespread implementation of garden-based learning, which could lead to perceived improvements in academic performance, increased engagement, and a more positive attitude towards Biology. Additionally, the practice of garden-based learning could provide learners with skills and knowledge that extended beyond academic performance, such as environmental awareness, healthy eating habits, and community engagement.

Future Researchers: For future researchers, this study contributed valuable knowledge to the existing body of literature on garden-based learning. The findings served as a reference point for future investigations into the area, potentially guiding the direction of subsequent research. Moreover, the study may have revealed gaps or areas of interest that had yet to be explored, thus providing future researchers with new research questions and opportunities for further investigation.

Scope and Delimitation of the Study

This study involved only a group of Grade-11 students enrolled in Earth and Life Science subjects in one of the senior high schools in the City Schools Division of Tanauan during the first semester of School Year 2020-2021 and has no plan to expand its scope to other groups of students. Hence, the observations of the study were taken with care and were analyzed within these assumptions of the study. Only the age and sex of the respondents were considered in the demographic profile because most of the literatures employed these variables in lower grade levels rather than higher grade levels, including senior high school. In addition, since students' learning engagement was a multifaceted concept consisting of different components or dimensions, the current research only utilized the commonly studied dimensions in educational research such as cognitive, emotional, and behavioral engagements in the context of garden-based learning environment. These dimensions would help the researcher to gain a more comprehensive understanding of how learners engage with educational activities in a garden-based learning environment, the factors that influence their engagement, and the potential outcomes of their engagement. provided in a garden-based environment. Also, this study focused on the seven (7) components of attitude towards Biology culled from various works of literature such as the importance of Biology, interest in Biology lessons, perceptions of the Biology teacher, keenness to learn Biology, enjoyment of Biology, anxiety towards Biology and effort in learning Biology. These components were also considered since the researcher opted to adopt the instrument Fetalvero (2016) used in his study.

The analysis of study was limited to establishing relationships between the extent of engagement in garden-based learning, academic performance, and attitude towards Biology of the respondents. There was no plan to expand this scope to other student factors and teacher factors.

Only the five plant-related topics from the Life Science subject were studied. The topics covered were characteristics of living things, photosynthesis, plant reproduction, plant form and function and energy flow in the ecosystem and biotic interactions. Hence, any utilization of the information derived from the study was considered this scope.

The learning activities, achievement tests, and other instruments that were utilized in the study were developed by the researcher, but they were validated by experts in the field. These activities were used by the student- respondents throughout the study.

The descriptive correlational approach was used in the study to identify the relationship. Analysis of the data and the consequent use of the information derived by the study should consider the assumptions associated with this design.

Chapter II

REVIEW OF RELATED LITERATURE AND CONCEPTUAL FRAMEWORK

This chapter presents related literature and other related scholarly discourse which address similar concerns to the current study. It also includes ideas, facts, and other information which the researcher gathered from books and other reading materials from which the present study was based. Moreover, conceptual framework and operational definition of terms were also presented.

> *"Learning comes alive in a school garden…Everything we know about good teaching is magnified in a school garden: student engagement, meaningful and relevant lessons, use of manipulatives, cooperative learning and exploration and discovery."*
>
> – Martha Deichler, Principal Vista Square Elementary School, Chula Vista, CA

A school garden is a living laboratory, an innovative teaching tool and strategy allowing educators to incorporate hands-on activities in their lessons. It engages students by providing a dynamic environment where they can observe, discover, experiment, nurture and learn independently. Rather than relying on the examples provided in the textbooks, school gardens provide an avenue for learning that draws from real-life experiences, thereby allowing students to become more active participants in the learning process (Cortero, 2019)

History of School Gardens for Education

Many educators have been advocates of school gardens and outdoor education. As far as the early 1600s, Europeans such as John Amos Comenius thought of school gardens as an opportunity for children to admire and appreciate trees, flowers, and herbs. Subramanian (2002) cited that in the 1700s, Jean-Jacques Rousseau stated that nature served as the child's greatest teacher and believed that knowledge of the natural world is a foundation for later learning. John Heinrich Pestalozzi supported the view of Rousseau and added that observation and activity in learning are also important rather than learning mere words. In the late 1700s to early 1800s, Froebel, the founder of kindergarten, was one of the most effective advocates of school gardens. Huckestein (2008) stated that Froebel recognized the significance of learning by observing, exploring, and doing. Following the same thought, Maria Montessori supported education for the senses first, then the education of the intellect (Subramaniam, 2002). Montessori felt that gardens had a profound effect on children. She stated, "When the student knows that life of the plants that have been sown depend upon his care in watering them…without which the little plant dries up… the child becomes vigilant, as one who is beginning to feel a mission in life" (quoted in Subramaniam, 2002). Throughout history, many famous educators have been advocates of hands-on, experiential, inquiry-based teaching. The famous American teacher and philosopher, John Dewey, strongly advocated experiential learning. He believed that education worked best when it started with the child's own experience (Raffan, 2000). All these early educators recognized the benefits of school gardens, outdoor education and learning by doing.

Gardens and garden projects have been built and utilized on the sites of schools throughout the history of the United States. In 1891, Henry Lincoln Clapp established the first US school garden at the George Putnam School in Roxbury, Massachusetts right after he was sent to the Massachusetts Horticultural Society to study school gardens in Europe (Smith & Motsenbocker, 2005). During that time, school gardens became a national movement that brought science into public view. Gardens were used primarily to teach students how to produce their own food and as a mechanism for moral, aesthetic, or civic uplifts and vocational/skills training. However, the use of school gardens was criticized by skeptics claiming that gardens ought to grow at home so that students focus on learning basic literary and other skills at school. In 1993, the American Horticultural Society held its first youth gardening symposium to bring together youth educators to brainstorm ways in which children's gardens could support educational curricula.

School Gardens and Learning

Garden-based educational programs show promise as meaningfully, culturally responsive, real-life, supportive contexts for promoting students' engagement and other important academic outcomes (Blair, 2009; Elliot, 2015; Fusco, 2001; Gaylie, 2011; Moore, 1997; Ozer, 2006; Williams & Dixon, 2013). A recent meta-analysis and synthesis of 48 research studies on garden-based learning from 1990 to 2010 showed positive effects on a variety of academic outcomes including science, language arts, and mathematics and on a variety of outcomes that indirectly support academics including the development of self-concept, change in eating habits, and positive environmental attitudes (Williams & Dixon, 2013). Most gardens examined in these studies were integrated with science classes (Klemmer et al., 2005a; 2005b; Rahm, 2002; Smith and Motsenbocker, 2005). Of the 40 studies assessing direct learning outcomes, 33 (83%) found positive effects. Fifteen studies using garden-based learning measured science outcomes, of which 14 showed positive effects. For example, in one study in Temple Texas, that used a sample of 647 students in grades 3-5 in seven elementary schools, Klemmer et al. (2005b) found that for those students who participated in hands-on school gardening program, science achievement scores were higher than for those students who did not participate. They concluded that constructivist, hands-on learning is a main feature of school gardens; hence, they “serve as living laboratories in which students can see what they are learning and in turn, apply that knowledge to real world situations”. As explained by Williams & Dixon (2013) and cited by Williams et al. (2018), “Soil chemistry, plant taxonomy, plant parts, flower dissection, water properties, seed germination and variety of seeds, insects and other wildlife, ecology, and environmental horticulture and insects and diseases”, were among the themes represented in the research studies that they analyzed.

Taken together, findings showed the potential of garden programs for benefitting academic and academic-related outcomes, especially in science. The integration of garden-based activities may likely be an important ingredient for science learning and shape students’ engagement and enthusiasm for science in the regular classroom. Cumulatively, engagement in the gardens and in science class may serve as a mechanism of personal transformation in a student’s academic identity, convincing students in the minority groups that they are “the kind of person who is needed and who can succeed in science (Saxton et al., 2014; Skinner et al., 2012).

Garden-based programs grounded in activities and teaching practices that are contextually, motivationally, and developmentally responsive have the potential to bolster engagement in science and other core subjects and may help counteract motivational declines typically observed during the transition to middle school (Eccles et al., 1993; Gottfried et al., 2002; Wigfield et al., 1992; Wigfield et al., 2015). Helping to mitigate or reverse motivational declines is especially valuable for students who might otherwise be at risk for underachievement and drop-out. Bringing together tenets of SDT and culturally responsive pedagogy, garden-based learning can provide authentic learning activities, promote positive teacher-student relationships, and nurture students' sense of belonging and connection to place, narrowing gaps in opportunities for relevant, high-quality learning for historically underserved students (Elliot, 2015).

Numerous studies were documented on the use of garden-based learning in various learning areas. In the survey conducted by Skelly and Bradley (2000), 84% of the teacher-respondents who were using gardens within the curriculum reported that gardening activities helped children learn better. Teachers also reported that gardening fostered experiential learning and facilitated teaching environmental education. In addition, Klemmer and colleagues (2005) examined the consequence of incorporating gardening within the science curriculum to the academic achievement of elementary school students. They found out that those who participated in the garden program scored higher on science achievement tests as compared to those groups who were not. Likewise, Ozer (2007) posited that involvement in the garden gave the opportunity for the children to showcase skills and areas of intelligence such as visual-spatial skills and physical strength that they might not have the opportunity to demonstrate when in a traditional classroom. This finding proves that gardening activities may promote academic success within specific subject areas when integrated into the curriculum as children get excited and interested in learning.

Garden-based Activities and Environmental Attitude

Students involved in the outdoor activity of school gardening had more positive environmental attitudes after gardening had more positive environmental attitudes after gardening regardless of the time spent, or number of activities completed, in the garden. In addition, demographic variables influenced results with female and Cuacasian students as well as students from rural areas, displaying more positive environmental attitudes after participation in the garden program compared to students from other groups. This information provides insight as to which populations might be targeted for more environmental education within the industry, and the population that might be recruited for future positions. Since the children of today will be future industry professionals, it is important to continue efforts to educate them to make good environmental decisions (Waliczek & Zajicek, 1999).

Gardens have increased environmental awareness because they give students the opportunity to experience nature. When describing how environmental attitudes are formed, Pe'er, Goldman and Yavetz (2007) emphasize the importance of connecting with nature at an effective level. The authors write that the effective part of environmental education is "concerned with the attitudes and values necessary to motivate the transformation of knowledge into responsible environmental behavior (p.46). You may also connect your discussions with the Naturalism intelligence of Howard Gardner and with the Naturalist philosophers.

Gardens help increase environmental awareness by allowing students to form environmental attitudes through hands-on experience. Regarding garden-based learning philosophy, Aarit (2002) speaks about how gardening guides children to personal discovery in a natural environment and explains how this process allows students to internalize important ecological ideas.

Morgan, Hamilton, Bentley, and Myrie (2009) speak of school gardening programs helping students become more environmentally aware. While studying, a garden program helps students become more environmentally aware. For instance, Morgan et al. (2009) reported that the children's positive experiences in the garden program in the inner city where they have fewer opportunities to interact with nature had enhanced their awareness of the outdoors and encouraged a favorable attitude towards the environment.

Garden-based Activities and Impact on Social/ Emotional Learning and Skills Development

Outdoor activities such as those with direct contact with the natural environment may also enhance children's social and emotional learning and personal development. It may facilitate behaviors conducive to learning. These areas of development are commonly ignored in traditional academics but given much emphasis in garden-based learning (Swank and Swank, 2013). In the study conducted by Robinson & Zajicek (2005), they examined the effects of a garden program on children's life skills development. Six areas of children's life skills development, namely, working in groups, self-understanding, leadership, decision-making, communication and volunteerism, were assessed following involvement in a one-year garden program. Findings showed that students engaged in the gardening activities demonstrated perceived improvements in their overall development particularly teamwork and self-understanding. The researchers concluded that accomplishing tasks could contribute to developing self-confidence and healthy self-esteem (Swank & Swank, 2013). Similar findings were observed by Sandel (2004), where youth developed insight into their own lives after participating in gardening activities while in the detention facility. Using their experience, students were able to draw a connection between taking care of a struggling plant in the garden and their continuous struggle to improve as a student in school. In addition, Sandel reported that group gardening projects may promote students' pride in oneself while also creating a sense of belonging, thus promoting social skills and teamwork.

Another study that shows the positive impact of gardening activities on students' self-confidence is that of Block et al. (2012). They found out that children's self-confidence was reinforced when they were able to self-direct and complete tasks assigned to them with minimal supervision. Parents, teachers, and program volunteers also reported that active involvement in garden and kitchen programs fostered self-esteem and independence among the participants. Thus, it is worth noting the remarkable impact of garden-based pedagogy on children's personal and emotional growth and development as demonstrated by the results of the studies of different researchers.

With regards to classroom behavior, Barros and colleagues (2009) as cited by Swank & Swank (2013) showed that teachers observed a significant perceived improvements in the classroom behavior of students who had at least one daily 15-minute period for recess. Moreover, researchers have found that exposure to the natural environment is helpful in reducing attention deficit symptoms among children (Kuo & Taylor, 2004; Taylor et al., 2001). Furthermore, the integration of gardening activities may facilitate student ownership, pride, a sense of belongingness and engagement with the learning environment (Block et al., 2012; Ozer, 2007). Researchers have found that positive school engagement served as a motivating factor that saved those who are disengaged at school from dropping and in turn can be correlated to high academic achievement (Hawkins et al., 2001). Consequently, children involved in gardening view the school environment positively, contributing to increased engagement.

In the Project Green Ranch garden program, Morgan et al. (2009) tell how this program teaches students that growing plants and friendships have similarities. Students in the program were able to work with partners, discuss their ideas about the garden, and speak in front of their peers.

According to Swank and Swank (2013), designing a comprehensive school counseling program that addresses students' academic, career, and personal/social development is a very challenging task for a school counselor. They suggested using a natural environment, like a school garden, to address student development. Based on their findings, school garden activities not only promote growth within individual areas of functioning (e.g. academic learning, social, and emotional development, health, connection with the school) but most likely in promoting change within systems (e.g. classrooms school, family, community) through collaboration with stakeholders (e.g. teachers and other school personnel, students' families and community volunteers). Hence, school gardens serve multiple purposes by promoting individual and systemic development within a natural environment.

Other studies have confirmed that gardens help students develop in ways beyond the academic curriculum. In their study of how outdoor activities involving nature can benefit students, Palmberg and Kuru (2000) discovered that students who had more outdoor experience were more willing to try new activities and work as a team. Students who did not have previous outdoor experience were more apprehensive about trying new activities and less enthusiastic about cooperating.

Garden-Based Learning and Experiential Learning

In a traditional teaching method, students must rely on memory and abstract thought to learn science concepts. On the other hand, in a classroom where experiential education is employed, hands-on learning allows students to be part of the learning process and not just mere spectators. This means that students become active participants in the teaching-learning process instead of just being passive receivers of information. And since they actively engage themselves in the learning process, their work becomes personally meaningful. It provides them the opportunity to engage in in-depth investigations of objects, materials, phenomena, and ideas and draw meaning and understanding from those experiences (Haury & Rillero, 1994).

Furthermore, Haury & Rillero (1994) best described the importance of experiential learning in science. According to them, science must be experienced to be understood. They stated, "By actually doing and experiencing science, students develop their critical thinking skills and discover scientific concepts." According to the National Academy of Science, as cited by Haury & Rillero (1994), students should experience science in an engaging form that fosters understanding at the earliest grades possible. In a case study by Miller(2007), he stated, "Experience is a powerful learning tool, and children remember hands-on learning." He also added that an experiential approach to teaching in a natural setting provides a way for teachers to help children to connect physically, intellectually, emotionally and spiritually with nature and give a chance to internalize their learning.

When teaching science outdoors, the scientific method can be used as a conceptual and hands-on learning process that stresses critical thinking, reasoning, and problem-solving skills. Subramaniam (2002) cited a study conducted by Bethel Learning Institute focused on student retention rates based on teaching methods. The study found that only 11% of information was retained during lectures, 75% for learning by doing while 90% when students shared/taught the information they learned to other students. Therefore, hands-on, experiential learning serves as the main idea behind most school garden programs as pointed out by Klemmer, Waliczek & Zajicek, (2005).

Ratcliffe (2017) describes garden-based as a learning strategy grounded by experiential learning. It encompasses programs, activities and projects in which the garden is the foundation for integrating learning, in and across disciplines. The integration is usually facilitated through active, engaging real-world experiences that have personal meaning for children, youth, adults and communities in an informal outdoor learning setting. Garden-Based Strategy (GBS) is an instructional strategy that utilizes the garden as a teaching tool. It draws on the basic principles of place-based education attempting to connect students to place and make curriculum relevant to life outside of the classroom. It is considered a form of direct experience in local places and often has components of environmental education with attention to ecology and stewardship. The experiential and contextualized aspects of GBS exemplify the importance of connecting the curriculum with students' everyday lives. In the garden, students do not require a high sense of their own capability in order to enthusiastically engage the learning activities; instead their participation is fostered by a sense of the personal importance and inherent enjoyment of the activities.

In addition, Ratcliffe et al. (2017) determined the effects of school garden experiences on middle-aged school students' knowledge, attitudes and behaviors associated with vegetable consumption. Their study revealed that GBS experiences may affect children's content and skills-based knowledge, academic and cognitive skills, social and moral development, and attitudes. It was cited that hands-on experiences in gardens or using the environment as a context for learning may increase students' knowledge of specific content areas including math, science, agriculture, botany and horticulture and may increase children's knowledge and development of life skills. GBS is expected to enhance academic skills and increase student's motivation, willingness to stay on task and adaptability to various learning styles. GBS experiences were supportive of positive youth development.

Despite the promising benefit we can derive from garden-based learning, additional research should still be conducted. It has been suggested that future researchers investigate whether the effects persist over time and whether garden experiences affect students' behavior towards their parents and guardians. It is also recommended to study the extent to which gardening contributes to maintaining the level of academic performance of the students. Comparative studies on different kinds of school garden interventions are deemed necessary to distinguish the most effective dimensions and components of garden-based learning.

Garden-Based Learning and Inquiry-based Learning

"Garden-based Learning", within a context of "Inquiry-based Science Education" [IBSE], can be defined simply as a set of instructional strategies that utilize a garden as a teaching and learning tool. The pedagogy is based on experiential education, which is practiced and applied in the living laboratory of the garden. Moreover, GBL has the potential to enrich basic education in all cultural settings. In cases where it is most effective, GBL is a pedagogy that is used with all children. It has something to contribute to each learning style and children at each developmental level. Garden-based learning offers a context for integrated learning. An integrated curriculum is often associated with real-life problems in contrast with a traditional subject–based curriculum. This provides a vehicle for higher order thinking skills as students are challenged to move beyond memorization, to see patterns and relationships and pursue a topic in depth, within a thematic approach. They are engaged in actively and socially constructing and construing knowledge, rather than passively accumulating and accepting information and they also develop analytic and synthetic thinking. At the practical level developing GBL skills raises the importance of (organic) gardening practice, through which children gain firsthand experience with the seed-to-seed cycle, the rhythm and traditions of the harvest, and the taste, touch, and smell of fruits, vegetables, and flowers. Proponents of children's garden programs talk of the multiple developmental benefits that school gardens can have on children namely, emotional, aesthetic, and even spiritual in addition to the more obvious social and intellectual benefits, in a variety of contexts (www.openschools.eu/portfolio-item/inspiring-project-2).

In a traditional classroom, learning is centered on a more structured, curriculum-centered framework. Teachers act as the source of knowledge and, along with administrators, school boards, and bureaucracy, determine what children should know and master (YouthLearn Initiative, 2001). Inquiry-based pedagogy taps student's natural gift of curiosity, especially when they are exploring their everyday world" (Boss, 2001). This pedagogy allows students to ask critical thinking questions and develop a sense of ownership since it allows them to become independent learners and construct knowledge by doing science.

When a hands-on method is used, students will be able to remember the material better, feel a sense of accomplishment when the task is completed, and transfer that experience easier to other learning situations. Other benefits of inquiry-based or hands-on learning include increased motivation, enjoyment, skill proficiency, independent thinking and decision making, and perception and creativity (Haury & Rillero, 1994).

Garden-Based Learning and the Philosophy of Naturalism

Naturalism is an education philosophy that emphasizes the role of nature in the development of the individual. It is based on the idea that education should be centered on the natural world and that the natural environment should be used as a primary source of learning. One of the key proponents of naturalism in education was John Dewey. Dewey believed that learners should be allowed to explore and learn through their own experiences and interaction with the world around them, rather than being confined to a traditional classroom. This means that outdoor activities and experimental learning are prioritized over traditional lecture-based instruction. The idea of John Dewey was supported by Maria Montessori, who emphasized that students should be allowed to learn through exploration and discovery, and the teachers should act as guides rather than authoritarian figures. In this light, the garden-based learning approach was often used as an educational tool in teaching and learning science and other learning areas.

Garden-based learning and naturalism share a common thread in their emphasis on connecting with and appreciating the natural world. While garden-based learning is often structured and focused on gardening activities, naturalism is a broader philosophy of observing and understanding the natural environment. However, both approaches encourage a sense of wonder, curiosity, and stewardship toward nature, making them complementary in fostering a deeper relationship with the natural world.

Garden-based learning involves actively engaging with the natural environment through gardening activities, which aligns with the naturalist perspective of observing and connecting with the natural world. Like the philosophy of naturalism, garden-based learning promotes environmental awareness among learners through experiential and hands-on activities involving taking care and cultivating plants, understanding ecosystems, soil health, interdependence of living organisms and appreciation of biodiversity.

In addition, garden-based learning and naturalism share elements of scientific observation. In garden-based learning, individuals often observe plant growth, behavior of insects, and changes in the environment, which can be seen as a form of informal scientific inquiry. Naturalists, too, engage in systematic observation and documentation of natural phenomena. And lastly, both garden-based learning and naturalism are closely connected to Howard Gardner’s Theory of Multiple Intelligence which suggests that incorporating various types of intelligences, such as naturalistic, interpersonal, intrapersonal, bodily-kinesthetic to name some, into garden-based learning programs can make education more inclusive and engaging, catering to the diverse strengths and abilities of individuals. This approach aligns with the principles of differentiated instruction, which recognizes that learners have unique talents and preferences for how they acquire knowledge and skills.

Learning Gardens in the Philippines

Since the 1970s, the Philippine government has been promoting vegetable gardening among elementary and high school students as part of the education curriculum (Salita, 2020; Bauzon, 2009; Innnocian and Nuneza, 2015). School gardening has been increasingly popular in the past decade both in developed (Ohly et al., 2016) and developing countries (Schreinemachers et al., 2017). However, most aimed to increase school children's knowledge of food systems and nurture their vegetable consumption. In 2010, the Department of Education (DepEd) collaborated with the Department of Agriculture (DA) in promoting the Gulayan sa Paaralan Program (GPP) (Vegetable Gardens in Schools) to address malnutrition among school children and at the same time promote vegetable production and consumption among pupils (DepEd 2007). Statistics showed that hunger and malnutrition are the two most common reasons Filipino students are forced to drop out of school. Complementing the hunger mitigation initiatives of the government, the Department of Education, through the Bureau of Learner Support Services- School Health Division (BLS-SHD), implemented the Gulayan sa Paaralan Program (GPP) which encourages both public elementary and secondary schools nationwide to establish vegetable gardens in their areas.

The GPP was issued and implemented through DepEd Memorandum No. 293, s. 2007 entitled *Gulayan sa Paaralan*. It is one of the sub-programs of the National Greening Program (NGP)of the Department, and it is tied up with the "*Programang Agrikultura para sa Masa*" of the Department of Agriculture at the national, regional, division/provincial/city levels. GPP seeks to raise public consciousness on the health and nutritional dimension as well as economic benefits of gardens (i.e. school, household, and community gardens); intensify production of locally grown fruits and vegetables; showcase small scale food production models to promote family food security; and inculcate positive values (e.g. good health and proper nutrition, industry, love of labor, and care for others).

After nine long years of its implementation, the Department issued another memorandum, i.e. DepEd Memorandum No. 223, s. 2016 strengthening the implementation of GPP in all public schools nationwide to achieve its goal of having gardens in all schools. In addition, DepEd also revived the School Inside a Garden (SIGA) initially launched through DECS Memo No.77, s.1995 which aims to focus primarily on making school campuses throughout the Philippines green and colorful by planting indigenous and endemic plant species and to further reinforce the DepEd's advocacy for the protection and preservation of the environment, as embodied in their core values MAKAKALIKASAN.

School gardening has been increasingly popular in developed and developing countries for the past decade. However, most studies that have been conducted on school gardening focus on educational goals and aim to increase school children's knowledge of food systems and their acceptance of vegetable consumption. In the study conducted by Inocian and Nuneza (2015), they documented the best practices of Talamban Elementary School's Gulayan sa Paaralan (TES-GP) in response to sustainable development. Specifically, their study aimed to determine the TES-GPs challenges and success stories, assess the physical features of the TES-GP, identify the type of vegetables planted, describe the garden model used in the TES-GP and perceive the guidelines for its successful monitoring. The Gulayan sa Paaralan was a modest replication of the Gulayan sa Masa and served as one of the best practices of TES-created a vital contribution to its feeding program. Pre-reflective awareness in responding to government mandates like sustainable development, hunger and malnutrition and other environmental challenges was a valuable piece for proximal impressions that led to the TES-GP's creation. The success of vegetable gardening was an attribute of passion in a seamless element of stretched consciousness for sustainable development, with a certain degree of sameness across the flow of time.

Through the joint efforts of the Southeast Asian Regional Center for Graduate Study and Research in Agriculture (SEARCA), the University of the Philippines Los Banos (UPLB) and the Department of Education (DepEd) Laguna, a Participatory Action Research on School-and Community-based Food and Nutrition Program for Literacy, Poverty Reduction, and Sustainable Development or dubbed as School-Plus-Home Gardens Project (SHGP) was implemented last January 2016. This project aims to improve the nutritional condition and dietary habits of school-aged children by increasing and enabling sustainable production of locally adapted vegetables through school and home gardening.

Studies also revealed that underweight and stunted and poor nutrition among 5 to 10-year old school children are among the pressing problems in the Philippines. This in turn leads to poor academic performance and early school dropouts. The declining interest in agriculture among youth is another major concern that needs to be addressed if food security in the future is a concern. To address these two issues, the Southeast Asian Regional Center for Graduate Study and Research in Agriculture (SEARCA) in collaboration with the University of the Philippines Los Baños (UPLB), and the Department of Education (DepEd) Laguna, revived and redesigned DepEd's earlier school garden programs to an innovative approach focusing on nutrition, education, and economic well-being of school children, their families, and their communities. This project was dubbed “A Participatory Action Research on School- and Community- based Food and Nutrition Program for Literacy, Poverty Reduction and Sustainable Development”, also known as the “School-Plus-Home Gardens Project (S + HGP). The S+HGP was piloted in six schools in the province of Laguna, Philippines with a model where harvests from the school gardens provided fresh vegetables for the school-based feeding program. The model also extended the gardening-feeding linkage to the establishment of food gardens in school children's homes. More than just establishing home gardens, the parents developed a greater responsibility to ensure good nutrition for their children, while saving on food expenses. It highlighted the multi-functionality of school gardens as learning laboratories for educating pupils, teachers, and parents about sustainability concepts and interconnections of food and nutrition, organic agriculture, edible landscaping, climate change, and solid waste management. Key project outcomes are discussed in five categories, namely, socio-cultural, technical, economic/financial, environmental, and policy-institutional. Mechanisms for sustaining and scaling up the initial success of the S+HGP were designed in a stepwise process, where the pilot schools took the lead to pay forward and share their knowledge with other schools, particularly, small schools in remote areas through intra-school and interdistrict networking. From the six original pilot schools in 2016, there are now two additional adopted schools, 23 sister schools, and three brother schools (Calub et al., 2019). This success of the S+HGP project gave the researcher an idea of replicating the project in his school and eventually in the whole Division of Tanauan City. However, due to the restrictions brought about by the Covid-19 pandemic, the current study will focus on home gardens instead of the combination of school and home gardens.

Theoretical Framework of the Study

The current study was guided by several theories such as the constructivist theory of Jerome Bruner, experiential learning by David Kolb, Multiple Intelligence by Howard Gardner and Self-Determination Theory (SDT) (Connell Wellborn,1991; Deci & Ryan, 2000 as cited by Skinner, 2015).

The constructivist theories guided the mode of instruction expected to facilitate learning through garden-based strategy. Constructivism is 'an approach to learning that holds that people actively construct or make their own knowledge and that reality is determined by the experiences of the learner' (Elliott et al., 2000:256). In this learning theory, students are viewed as active participants who construct their understanding of concepts, and as meaning-makers who can transfer pre-organized knowledge. It aims to develop individuals with multiple viewpoints and advanced problem-solving skills who can defend and organize their thoughts. In a constructive setting, the person taking the responsibility is expected to have skills such as initiative-taking, self-expression, communication, critical thinking, planning and practicing what they have learned in real life settings. Constructivism affects not only the reconstruction of knowledge but also practices such as the application of hands-on and experiential learning in science education and central to fundamental education.

Constructivism has been cited as a major influence on science education in the last 20 years, according to Niaz (2015). It focused on people and was predicated on the notion that students are deeply interested in and accountable for their own learning. While there are many interpretations of constructivism, the most common belief was that students learn by constructing their own knowledge. While constructivism has many interpretations, the most common belief was that people learn by building their own knowledge rather than having it transferred down from generation to the next. Students who take an active role in exploring ideas on their own will not only be able to realize what they are learning, but they will also be inspired to clarify why their own assumptions are right.

On the other hand, experiential learning theory was used in the study as another framework for successful science education by reflection on experience. Experiential learning theory considers individuals gaining and constructing information by engaging with the world through a series of perceived experiences.

Experiential education is a process through which a learner constructs knowledge, skill, and value from direct experiences. According to Kolb’s experiential learning model (Kolb, 1975 in Weatherford & Weatherford, 1987) concrete experience leads to observations and reflections. These, in turn, result in the formation of abstract concepts and generalizations of these concepts as well as the capacity to test the implications of these concepts in new situations. In a socio-ecological model of a child’s outdoor landscape (Moore & Young, 1978), it is proposed that a child lives simultaneously in three interdependent realms of experience: the physiological-psychological environment of body/mind, the sociological environment of interpersonal relations and cultural values, and the physiographic landscape of spaces, objects, persons and natural and built elements. The freedom of the outdoor environment balances a child's supervised indoor environment, resulting in volitional learning.

Intelligence is identified in reference to a socially recognized and valued role that appears to rely heavily on a particular intellectual capacity (Gardner, 1999). Gardner suggests that we have at least eight intelligences, namely, linguistic, musical, logico-mathematical, spatial, bodily kinesthetic, intrapersonal and interpersonal and that only two-logico-mathematical and linguistic-are given importance in schools. The latest addition to the seven intelligences, naturalistic intelligence is defined as the person's ability to recognize and classify his or her natural environment. Gardner claims that just as children are ready to master language at an early age, so too are they predisposed to explore the world of nature (Gardner, 1999). When the method of instruction is geared toward all the different types of intelligence, a learner can be said to have learned more completely, having an opportunity to use his or her different learning styles (Drake, 1998).

The researcher also adapted the Self-Determination Theory (SDT), a motivational model, focused on engagement, for use in explaining the effects of garden-based learning on student achievement and positive development. The central idea is that the defining features of garden-based programs, which offer holistic, integrated, hands-on, project-based, cooperative, experiential learning activities, are intrinsically motivating and have the potential to meet fundamental needs of children and youth, thereby fostering engagement. The need for relatedness (to feel they are welcomed and belong) can be met by cooperation with classmates, teachers and master gardeners on a project highly valued by the entire community. The need for competence may be met by experiences in problem-solving, effort, and persistence that pay off in tangible outcomes. Most importantly, gardening introduces authentic and meaningful activities, potentially instilling pride and ownership. This supports autonomy, a need that is increasingly important and increasingly undermined by schooling as students approach adolescence (Eccles et al., 1993). Garden-based learning could enhance student constructive engagement by supporting students' experience of themselves as connected and related to the garden, competent to carry out science and gardening activities, and autonomous in their sense of purpose and ownership of the garden. These experiences, as crystallized in students' self-perceptions, are the proximal predictors of the quality of students' engagement with learning activities and their resilience in the face of challenges and setbacks, which contribute to their learning and long-term achievement. Strong empirical support has been found for each link in the SDT model. Research confirms that both student self-perceptions and teacher motivational support shape classroom engagement.

Conceptual Framework

The paradigm of the study is shown in Figure 2.1 which provided a visual representation of the relationship of the variables that were investigated in the study.

As indicated in Figure 2.1, the extent of students' engagement in a garden-based learning environment influences their academic performance in science and attitude towards Biology. Such an influence may be affected by their age and sex.

. The implementation of garden-based educational activities involves hands-on learning experiences and curriculum integrated into a garden setting such as planting, observing, and experimenting with plants and ecosystems. These activities were assumed to affect students' attitude towards Biology and academic achievement in Science.

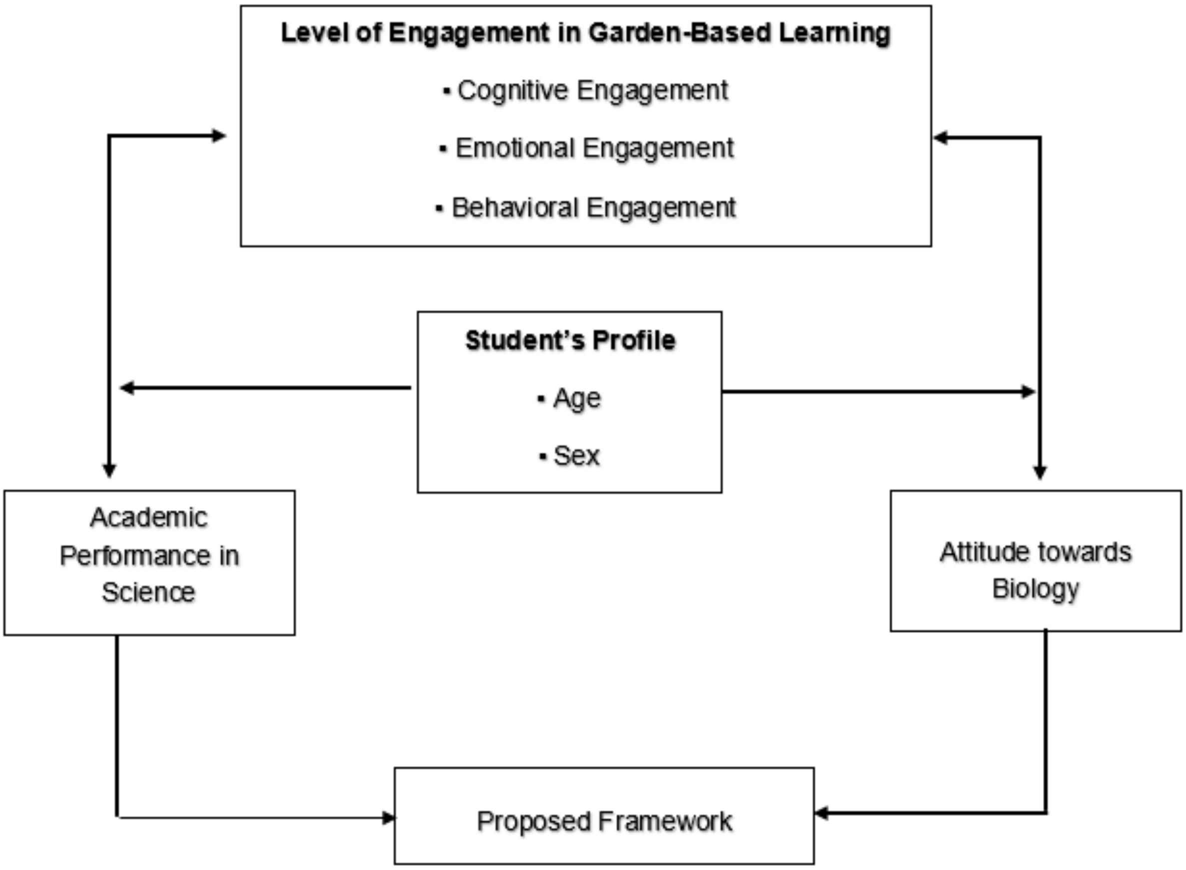

Figure 2.1. Conceptual Framework of the Study

The measure of students' learning engagement took into account three components, namely, cognitive, behavioral, and emotional engagements. Cognitive engagement refers to the learners' willingness to expand or apply extra effort on learning to the cognitive processing a student brings to academic tasks as well as the range of strategies they employ (Walker, Greene, & Mansell, 2006). On the other hand, behavioral engagement includes the observable actions, behaviors, and participation of students in educational activities (Skinner, Chi, & The Learning-Gardens Educational Assessment Group, 2012). It involves the extent to which students actively participate in the learning process, complete their academic tasks, and adhere to classroom rules and expectations (Fredericks et al., 2004). Behavioral engagement can include behaviors such as attending classes regularly, being punctual, following instructions, completing assignments and homework, participating in class discussions, and showing appropriate classroom conduct. The emotional engagement is the learning engagement component that reflects the emotional and affective aspects of a student's connection to the learning process. It is the learners' reactions to learning and learning environments (Fredericks et al.,2004) and may include self-reporting or visible positive emotion expressions (Ding et al., 2018) such as enjoyment, fun, interest and enthusiasm while learning (Skinner, Chi, & The Learning-Gardens Educational Assessment Group, 2012). This means that students who are emotionally engaged are often genuinely interested in the subject matter and find it personally meaningful. They are intrinsically motivated to learn because they see value in the knowledge or skills being acquired. They also tend to have positive attitudes toward learning and are more likely to view challenges as opportunities for growth rather than as obstacles. Lastly, they derive enjoyment from the learning process itself, making them more likely to be active and persistent learners.

The study assumed that these components of learning engagement had an association with the attitude of students towards Biology and their academic achievement under a garden-based learning environment. As indicated in various literature (e.g. Saxton et al., 2014; Skinner et al., 2012; Eccles et al., 1993; Gottfried et al., 2002; Wigfield et al., 1992; Wigfield et al., 2015), garden-based learning grounded in activities and teaching practices that are contextually, motivationally, and developmentally responsive have the potential to bolster engagement in science and other core subjects. Ozer (2007) also indicated that students' engagement in garden-based learning activities can give them the opportunity to showcase their skills and areas of intelligence and thus, allow them to score higher on science achievement tests as compared to those groups who were not.

Learning engagement and attitudes toward biology are critical aspects of science education. In biology education, the concept of learning engagement has gained increasing attention (Fredricks, Blumenfeld, & Paris, 2004). Learning engagement consists of cognitive, behavioral, and emotional involvement in learning activities. In biology education, students who are actively engaged tend to explore biological concepts more deeply, ask questions, and express enthusiasm for the subject. When students are actively engaged in the learning process, they are more likely to develop a genuine interest in the subject matter. This increased interest can lead to a more positive attitude towards biology, as students may find the content more engaging and relevant. One way to improve student attitude toward science is through teaching methods (Erdemir, 2009; Singh, 2002). Active learning methodologies, such as problem-based learning (Prince, 2004), inquiry-based learning (Sundberg & Dini, 1993), and garden-based learning (Waliczek, 2003 & Williams et al., 2018), have been found to enhance engagement. The better engagement of students results in a better attitude to Biology and learning in Biology (Jamphel & Kinley, 2022). These techniques allow students to explore biology concepts actively and collaboratively. This research supports the findings of Bell, Blair, Crawford, and Lederman (2003), who discovered that inquiry-based learning experiences improve students' attitudes about biology. Encouragement of students to engage in scientific research, according to them, creates a greater grasp and appreciation of biological processes. Similarly, in the study conducted by Skinner and Chi (2011), student garden engagement was positively correlated with student perceptions of how much they learned in the garden, students' actual grades (GPA) in core subjects, and students' self-perceptions of their competence, autonomy, and intrinsic motivation in the garden, as rated by both students and teachers. Additionally, engagement in the garden was positively correlated with both student and teacher reports of students' academic engagement and students' self-perceptions of their sense of relatedness, competence, intrinsic motivation, and autonomy in school.

Effective teaching practices and teacher enthusiasm also play crucial roles in improving attitudes and engagement in biology (Patrick et al., 2000). Enthusiastic teachers can inspire students and create a positive classroom atmosphere. According to the findings of the study done by Bawang and Prudente (2018), the use of flipped classroom approach in teaching physics considerably improved the level of engagement of the students before and after intervention which in turn, improved the students' attitudes about learning physics. This just implies that the student's level of engagement can result in the development of favorable attitudes or perceptions regarding their science subject.

Attitude towards Biology reflects the respondents' feelings, interests, and perceptions regarding Biology and the natural world which can be assessed using surveys or questionnaires. While the academic achievement in science is one of the key outcome variables, representing respondents' academic performance in science which can be measured using teacher-made achievement tests. In addition, the demographic profile such as age and sex are the moderating input variables of this study wherein it will be analyzed if there are differences in learning engagement between male and female across age. The line that links the demographic profile such as age and sex, to academic achievement and attitude towards Biology indicates that age and sex can have an impact both on the students' learning engagement towards garden-based learning, their attitude towards Biology and to their academic achievement in science. This indicates that different age groups may respond differently to garden-based learning, with younger students possibly experiencing more significant changes in attitude and achievement. Furthermore, the impact of garden-based learning on attitudes towards Biology and achievement in science may vary between males and females.

This study aims to explore science engagement as a potential mediator to achieve enthusiasm amongst students to take an interest in garden-based learning. It is assumed that students' enthusiasm about learning in the garden may strengthen the connections these activities provide between science and the real world outside the classroom, boosting their interest and curiosity about science learning activities. Since these engaged emotions seem to promote engaged behaviors, like effort and persistence in learning activities (Skinner et al., 2008), the researcher thought that they might be one pathway through which garden engagement contributes to achievement in science.

The results and findings of this research can inform educators and curriculum developers about the potential benefits of incorporating garden-based learning into science education to enhance science achievement and promote environmental education among learners, considering age and sex differences in program design and implementation.

Definition of Terms

For the purpose of this research, some terms are conceptually and operationally defined to shed understanding on important terms used in the study.

Academic Performance. According to Narad and Abdulla (2016), it refers to the outcome of education, the extent to which a student, a teacher or institution has achieved their educational goals over a certain period and is measured either by examinations or continuous assessments. In this study, this refers to the scores obtained by the students on the researcher-developed life science achievement test (LSAT) administered after being exposed to the intervention.

Attitude towards Biology. It is defined as an affective concept which are the feelings, beliefs, and values held by an individual about an object that may be enterprise of science, school science, the impact of science on society or scientists themselves (Osborne, Simon & Collins, 2003). In this study, this refers to the students' overall score in a 51-item Attitude Towards Biology Scale (ATBS) adopted from Fetalvero (2016) which is composed of seven components as indicated below:

Importance of Biology. It refers to the significance, value, and relevance (Encarta, 2009) of biology as perceived by the students. It is operationalized in this study as the average score of a student in 10 statements of ATBS (Fetalvero, 2016).

Interest in biology lessons. It indicates the students' feelings of curiosity or concern about Biology that makes their attention turn toward it (Encarta, 2009). The term is used in this study to refer to the average reversed score obtained by a student in eight negative statements depicting disinterest in biology lessons (Fetalvero, 2016).

Perception of the biology teacher. It refers to the students' impression, an attitude or understanding based on what is observed or thought (Encarta, 2009). It is contextualized in this study as the students' average score in eight statements of ATBS (Fetalvero, 2016).

Keenness to learn Biology. It indicates the student's enthusiasm, eagerness and willingness (Encarta, 2009) to learn biology. As used in this study, it refers to the average score of students in eight statements of ATBS (Fetalvero, 2016).

Enjoyment in Biology. It refers to the student's pleasurable experience of neology (Encarta, 2009). It is used in this study to refer to the student's average score in eight statements of the ATBS (Fetalvero, 2016).

Anxiety towards Biology. It is the student's feeling of worry, nervousness or agitation (Encarta, 2009) about the subject. This is operationalized as the student's average reversed score in five statements of ATBS (Fetalvero, 2016).

Effort in learning Biology. It refers to the mental or physical energy exerted (Encarta, 2009) by a student in order to learn Biology. In this study, it is operationalized as the student's average score in four statements of the ATBS (Fetalvero, 2016).

Garden-based Activities. In this study, this refers to student-centered learning activities characterizing cooperation, active and engaging hands-on activities using the school garden, a unique opportunity to learn biodiversity and life science concepts.

Garden-based Education. It is defined as a philosophical orientation to teaching and learning that uses gardens as the milieu for student engagement through meaningful and relevant curricular and instructional integration in schools (Williams, 2018). In this study, it refers to the

Garden-based Learning. Is an instructional strategy that utilizes the garden as a teaching tool. It encompasses programs, activities, and projects in which the garden is the foundation for integrated learning, in and across disciplines, through active, engaging and real-world experiences (Desmond, Grieshop & Subramaniam, 2002). In this study it will be used as the main teaching strategy in learning life science by having the subject-related activities and performance tasks within the school garden serving as an alternative milieu for learning.

Home Garden. It refers to a small portion of land or a plot of land, individually owned, which may be around the household or within working distance from the family home and usually planted with vegetables and/ornamental plants. This study may refer to the place or area at home where garden-based activities will be performed. This may also include the student dish garden that will serve as their outdoor laboratory.

Experiential Learning. This is a method of educating through first-hand experience whereby knowledge is created through the transformation of experience. As taken in this study, this refers to the hands-on, practical, and immersive experiences of the students within a garden environment as a means of acquiring knowledge, skills, and attitudes related to biology and environmental science.

Learning Engagement. It is the ability of the learners to motivationally and behaviorally engage in an effective learning process. This study, refers to the students' responses in the 41-item Learning Engagement Survey Questionnaire (LESQ) adapted and modified from Appleton et al. (2006) and Lam & Jimerson (2008), which is composed of three components as follows:

Behavioral Engagement. A component of the learning engagement that entails exertion of effort, focused attention, persistence, and hard work on academic activities (Skinner, Chi, & The Learning-Gardens Educational Assessment Group, 2012). As used in this study, this refers to the average score of students in 14 statements in the LESQ.

Behavioral engagement includes completing work and adhering to rules (Fredericks et al., 2004). Behavioral engagement includes learner effort, persistence, participation, and adherence to the structure, which is critical for achieving positive academic outcomes and preventing dropouts.

Cognitive Engagement*.* A component of the learning engagement that encompasses learner's willingness to expand extra effort on learning to the cognitive processing a student brings to academic tasks as well as the amount and type of strategies a student utilizes (Walker, Greene, & Mansell, 2006). As used in this study, this refers to the average score of students in 13 statements in the LESQ.

Emotional Engagement*.* A component of learning engagement that refers to learners' reactions to learning and learning environments (Fredericks et al.,2004). It may include self-reporting or visible positive emotion expressions (Ding et al., 2018) such as enjoyment, fun, interest and enthusiasm while learning (Skinner, Chi, & The Learning-Gardens Educational Assessment Group, 2012). As used in this study, this refers to the average score of students in 14 statements in the LESQ.

Very High Extent of Engagement: This term refers to the highest level of involvement, commitment, or participation in a given activity, task, or context. Individuals displaying a very high extent of engagement are fully immersed, highly motivated, and actively contribute their time, effort, and resources.

High Extent of Engagement: High extent of engagement indicates a substantial level of involvement, commitment, or participation in a specific situation or endeavor. Individuals with a high extent of engagement demonstrate a strong interest, dedication, and willingness to invest in the task or activity.

Low Extent of Engagement: Low extent of engagement suggests a limited or minimal level of involvement, commitment, or participation in a particular context. Individuals with low engagement may show only mild interest, lack of motivation, or a reduced willingness to invest in the task or activity.

Very Low Extent of Engagement: This term represents the lowest possible degree of involvement, commitment, or participation in a given situation. Individuals with very low engagement exhibit little to no interest, motivation, or willingness to engage with the task or activity, often leading to disinterest or detachment.

Student Achievement. The degree that students can demonstrate learning on standardized learning assessment tools. These tools are designed to measure student performance as a result of delivered instruction (Cunningham, 2012).

Chapter III

METHODOLOGY

This chapter describes the research design, the subjects of the study, instruments, data collection procedure, and data analyses. The detailed methodological techniques are described in this chapter and comprise of the following: (a) course overview, (b) research design, (c) subjects of the study (d) research instruments, (e) data collection procedure and (f) statistical analysis.

Study Context: Course Overview

Earth and Life Science is one of the core subjects under natural sciences that is offered every first semester of the school year. This subject is being taken by all Grade-11 students regardless of their track except for those who are enrolled in Science and Technology, Engineering and Mathematics (STEM) strand where Earth and Life Science should be taken as separate subjects. This learning area is designed to provide a general background for understanding Earth Science and Biology. It presents the history of the Earth through geologic time. The first half of the subject is Earth Science, which discusses the Earth's structure, composition, and processes. Issues, concerns and problems pertaining to natural hazards are also included. The other half is Life Science, which deals with the basic principles of the study of living things. It covers life processes and interactions at the cellular, organism, population, and ecosystem levels. Specifically, it tackles the following contents: characteristics of living things, photosynthesis, plant reproduction, plant form and function, and energy flow in the ecosystem and biotic interaction.

This subject is delivered for four (4) hours per week through the traditional "chalk and talk" approach and 1 hour per week for independent cooperative learning (ICL) where students form a small group and work together to accomplish a common task or they may share and give their own ideas and understanding about certain topic/s they have discussed for the week. However, due to several learning competencies to be covered within a very limited time, a teacher-centered approach is usually employed instead of student-centered and inquiry-based approach as prescribed by K to 12 Science curriculum. As a result, students perform poorly in this subject as depicted by the subject's mean percentage score (MPS) of 70%, which is lower than the 75% target every quarter, in addition to quite a few least mastered learning competencies which require remediation. This problem has been encountered by the school for almost four years already.

Research Design

Research design was commonly defined as the way of thinking and doing preparation to complete research and achieve the goal of the research. In order to ascertain a significant relationship among the variables, the descriptive-correlational research design was utilized in the study. Correlation design was quantitative research in which investigators measured the degree of relation between two or more variables using the statistical procedure of correlation analysis. The degree of association, expressed as a number, indicated whether the two or more variables were related or whether one could predict another (Ubolwan, 2013).

To understand if there was and to what extent a relationship existed between the engagement of the students in garden-based learning and their academic performance and attitude towards Biology, a correlational study was aligned with this study. A correlational design is a non-experimental approach to research (Haines, 2020). A correlational approach is appropriate for evaluating the direction and strength of a relationship (Curtis, Comiskey, & Dempsey, 2016). A correlational study was used to evaluate the relationship between two or more variables (Stangor & Walinga, 2019).

Focus group interviews were conducted as part of the qualitative analysis to provide a more in-depth understanding of how respondents perceived the approach and use of garden-based learning. This was further confirmed by cross-referencing the responses to an attitude questionnaire, activity reports from the students, reflection journals, and in-depth, probing interviews.

Subjects of the Study

The subjects of this study were the Grade-11 students in Pantay Integrated High School, one of the senior high schools in the Schools Division of Tanauan City, who were enrolled in Earth and Life Science subjects during the first semester of School Year 2020-2021.

Since this study wanted to investigate the effectivity of garden-based learning approach, the target population was generally set to all Grade-11 students who have available gardens at home. Specifically, the researcher set the following inclusion criteria for the target population of the study: (a) officially enrolled in the subject regardless of their track and strand; (b) regardless of their sex; (c) have a small piece of land near their house intended for gardening; (d) willing to take part in the research; (e) given permission by their parents to participate in the research; and (f) their residence is near the school so that the researcher would be able to supervise them as they conduct the garden-based activity and ease in the distribution of the needed materials for the activities. Given these inclusion criteria, a total of seventy students, 36 of which are male and 34 are female, was identified to participate in this study. A complete enumeration was employed in this study given the identified target population.

Research Instruments

The Garden-Based Learning Manual. This manual (refer to Appendix E) was composed of fourteen (14) garden-based learning activities modified by the researcher from existing laboratory manuals in Biology. The activity manual contained the title of the activity, objective(s), materials to be used, step-by-step procedure on how the activity/experiment would be carried out, guide questions, application, and conclusion. These activities were intended to supplement the existing curricula and did not build upon each other. The activities were developed using a student-centered framework where students were provided with the opportunity to become active and creative investigators. They were expected to develop their critical thinking skills by conducting experiments or performing research activities. They were also expected to develop their science process skills and positive attitudes towards the subject matter. The developed manual was validated by three Biology teachers.

Life Science Achievement Test (LSAT). This was a researcher-made test that measured students' academic performance in the subject as indicated in their score obtained in the achievement test that was administered after the implementation of the intervention (Refer to Appendix I). It was a multiple-choice test with four plausible choices and one correct answer. The books written by Baltazar (2016), Moncada

(2016), Salandanan et al. (2016) and Earth and Life Science Teacher's Guide provided by DepEd served as the learning resource materials and source of the achievement test questions. The items were adapted and modified by the teacher-researcher and were subjected to expert validation. Three experts in the field of Biology validated the test for its content and accuracy using the validation of the written content questionnaire form. The result of the evaluation as well as the comments and notes made by the content experts were considered in the revision of the test questions. Items that were considered unsuitable were revised to preserve their distribution in the table of specification (Table 3.1). After the face and content validation, a trial run was conducted, which involved 30 Grade-12 students who have already taken the subject to determine the reliability value of the test. Based on the result of the pilot test, Kuder-Richardson 20 (KR-20) coefficient were performed to assess the internal consistency and reliability of the Life Science Achievement Test (LSAT) for post-test. The KR-20 coefficient is commonly used to estimate the consistency of a test by measuring the extent to which the items in the test are measuring the same construct. In this case, the KR-20 coefficients were computed for different topics within the LSAT, as well as for the test as a whole. Based on the result of the reliability test, a KR-20 coefficient of 0.751 was generated which is above the commonly accepted threshold of 0.70 for a test to be considered acceptable in terms of internal consistency. The reliability statistics indicate that the LSAT, in general, and its individual topics, in particular, demonstrate high levels of internal consistency and reliability. This suggests that the LSAT is a dependable instrument for assessing students' knowledge and understanding of various life science topics, including characteristics of living things, photosynthesis, plant reproduction, plant form and function, and energy flow in the ecosystem and biotic interactions. The findings support the use of the LSAT as an effective tool for evaluating students' comprehension and retention of key life science concepts.

Table 3.1. Table of Specification and Reliability of the Life Science Achievement Test (LSAT)

	Item Number					
Topic	**Remembering/ Understanding**	**Analyzing/ Evaluating**	**Applying/ Creating**	**f**	**%**	***a***
1. Characteristics of Living Things	1,3,6,8	2,4,5,7,9,10	0	10	10	0.995
2. Photosynthesis	12-15, 18, 24-28	11,16,17,19-23, 29-30, 32-35	31	25	25	0.994
3. Plant Reproduction	37-40,45-49	36,41,43,44,50	42	15	15	0.990
4. Plant Form and Function	52,54-56, 63,67,71,72	51,57-62, 64,68,69,70, 73-75	53,65,66	25	25	0.996
5. Energy Flow in the Ecosystem and Biotic Interactions	77,79,81, 86-89,91,99	76,80, 82-84, 90,92,93,95,97	78,85,94,96, 98,100	25	25	0.996
TOTAL	**40**	**49**	**11**	**100**	**100**	**0.751**

Attitude Towards Biology Scale (ATBS). This is a 51-item instrument (Appendix G) used by Fetalvero (2016) in his study on Consensus-based instruction and its effect on students' attitude towards Biology and achievement in bioenergetics. The items from this instrument were lifted and modified by Fetalvero (2016) from various research literatures which covered components of students' attitude toward science, (which the author replaced with the word "biology) such as specific feelings toward biology, motivation to achieve biology, biology anxiety, attitude towards biology teacher, attitude towards biology curriculum, keenness to learn biology, enjoyment in biology learning, disinterest, teacher interaction, importance of biology, interest in biology lessons, and understanding biology process. The researcher chose this instrument since the characteristics of the individuals of the study employed by Fetalvero (2016) and the current study are very comparable in terms of age, taking up science related disciplines, and being non-science majors.

The present study has adopted this instrument with permission from the author since it has already undergone content validation by the experts and has a high reliability value as shown in its generated Cronbach's alpha value of 0.922 for the whole test. This means that the instrument is an excellent scale in measuring the students' attitude towards Biology, which is one of the variables being studied in the present study. Using this instrument, students were asked to respond by expressing their degree of agreement or disagreement to each statement using a four-point Likert type scale, 1 as strongly disagree, 2 as disagree, 3 as agree and 4 as strongly agree. Table 3.2 shows the structure and reliability of the attitude towards Biology scale.

Table 3.2. Structure and Reliability of the Attitude Towards Biology Scale (adopted from Feltavero, 2016)

Factor	**Label**	**No. of Items**	**Item Placement**	**α**
1	Importance of Biology	10	1,2,4,7,27, 31,39,45,46,48	0.862
2	Interest in Biology Lessons	8	8*,19*,22*,23* 30*,38*,42*,44*	0.830
3	Perceptions of the Biology Teacher	8	21,25,35,40 41,43,47,51	0.846
4	Keenness to learn Biology	8	10,17,18,20 28,29,33,36	0.817
5	Enjoyment of Biology	8	3,5,6,15 24,26,32,37	0.820
6	Anxiety Towards Biology	5	9*,11*,14* 16*,50*	0.764
7	Effort in Learning Biology	4	12,13,14,49	0.790
TOTAL		**51**		
Whole-Scale Reliability				**0.922**

*negative statement, scoring reversed

Learning Engagement Survey Questionnaire (LESQ). This was a researcher-made, self- report survey questionnaire, composed of 41-item questions focused on the comprehensive assessment of the construct of engagement towards garden-based learning (Appendix F). The items from this instrument were drawn from the existing research instruments developed by Appleton et al. (2006) and Lam & Jimerson (2008) to measure students' learning engagement and categorized only into three dimensions of engagement: cognitive engagement, emotional engagement, and behavioral engagement. Students were asked to respond to each statement according to the Likert scale of 1-4 (i.e. 1 as strongly disagree, 2 as disagree, 3 as agree and 4 as strongly agree). Three science education researchers/faculty members reviewed and critiqued this instrument. Furthermore, a faculty member, specialized in education psychology, was asked to review the modified instrument to check if the items best suit for the intended respondents and study. The instrument was revised according to their comments and suggestions.

The instrument was pilot tested on 30 Grade-12 who have taken the Earth and Life Science subject to determine the language suitability of the items and ease in following directions by the students. They were also being encouraged to identify words or statements in the instrument that were vague or unclear to them. Their comments and suggestions were used in the final revision of the instrument. To test the reliability of the instrument, the value of Cronbach alpha test of reliability was measured. A reliability of 0.80 to 0.90 was considered very good (Nunnaly, 1967). The structure and reliability of the Learning Engagement Survey Questionnaire was shown in Table 3.3.

Table 3.3. Structure and Reliability of the Learning Engagement Survey Questionnaire

Factor	Label	Total No. of Items	Item Placement	α
1	Cognitive Engagement	13	3,8,11,13, 17,20,21, 26,29,32, 33,35,37	0.912
2	Emotional Engagement	14	1,6,9,10,12,15 ,18,23,24,25,3 1,36,38,41	0.819
3	Behavioral Engagement	14	2,4,5,7,14,16, 19,22,27,28,3 0,34,39,40	0.827
	TOTAL	**41**		0.926

Questionnaire on Students' Perception Towards Garden-based Learning. This questionnaire (Refer to Appendix H) was used to assess the perception of students towards the use of garden-based learning. The questionnaire was composed of twenty (20) items describing the positive impacts of garden-based learning on the learners as cited from various research literatures. It was reviewed and critiqued by the experts who validated the LESQ and LSAT. After all the comments and suggestions were incorporated, the instrument was pilot tested to a selected small group of Grade-10 students in order to get the Cronbach alpha test of reliability value. Using this tool, the students were asked to respond by expressing their degree of agreement or disagreement with each statement using a four-point Likert scale.

Interview Questionnaire. This was the tool intended for the qualitative portion of this study. It was a personal interview questionnaire used to get the students' perceptions as they were taught using the garden-based learning approach. Specifically, the instrument collected students' experience with the teaching approach, the problems encountered, attitude and behavior towards the strategy, and suggest whether it can be used for future life science classes.

Data Collection Procedure

Permission from the Schools Division Superintendent and School Head (Refer to Appendix A and Appendix B) was sought to introduce the proposed intervention among the students enrolled in Earth and Life Science in the chosen senior high school. Two weeks before the end of the first quarter of first semester of School Year 2020-2021, the researcher conducted a virtual meeting for parents via google meet to discuss the objectives of the research, the research procedure, the ethical measures to be taken and the rights of the participants. The parental consent form was disseminated while retrieving the activity sheets and distributing self-learning modules. Those students allowed to participate in the research were given the Garden-based manual and the Alternative Delivery Mode (ADM) module given by the Department of Education (DepEd).

Implementation Strategies. First, an online orientation was conducted to help students familiarize themselves with the GBL approach. The researcher discussed the concept of GBL, its process, advantages and limitations, expectations from students and teacher, learning aims and schedule and/or duration of the study. In addition, the schedule of distribution and retrieval of learning packages and the minimum health protocols that needed to be observed were also presented. Since physical face to face session was still not allowed because of the Covid-19, an alternative delivery mode (ADM) modules crafted by science teachers in Region IV-A (CALABARZON) were used by the student-respondents throughout the implementation of the study. Each ADM module was designed to address the Most Essential Learning Competencies

(MELCs) for Earth and Life Science per week as the Department of Education prescribes. The activities contained in the modules were arranged according to graduated levels of difficulty- from simple to complex, following the IDEA instructional process. The IDEA instructional process followed four (4) main teaching-learning phases and each phase has a corresponding activity in the module that students need to accomplish (refer to Table 3.4).

Table 3.4. IDEA Instructional Process and the Parts of ADM Modules

IDEA Instructional Process	Parts of ADM Module	Description
Introduction	***What I Need to Know***	This will give an idea of the skills or competencies that students should learn using the module.
	What is New	In this portion, the new lesson will be introduced to the students in various ways such as a story, a song, a poem, a problem opener, an activity or a situation.
Development	***What I Know***	This part includes an activity that aims to check the prior knowledge of students
	What is In	This is a brief drill or review to help students link the current lesson with the previous one.
	What is It	This section provides a brief discussion of the lesson. This aims to help students discover and understand new concepts and skills.
Engagement	***What is More***	This comprises activities for independent practice to solidify students understanding and skills of the topic
	What I Can Do	This section provides an activity that will help students apply their new knowledge or skill to real-life situations or concerns.
Assimilation	***What I Have Learned***	This includes questions or blank sentence/ paragraphs to be filled in to process what students learned from the lesson.
	What I can Achieve Weekly Assessment	This is a task which aims to evaluate students' level of mastery in achieving the learning competency.
	Additional Activities	In this portion, you will be given another activity to enrich your knowledge or skill of the lesson learned. This also tends retention of learned concepts.

During the distribution of learning package, students who were given the permission to participate in the study received a copy of garden-based activity sheet and the necessary materials in order to perform the GBL activity, in addition to the usual contents of the learning package such as learner's module, weekly home learning plan and learning activity sheets. Furthermore, garden-based activities were incorporated in some parts of the lesson plan specifically in the engagement phase, thus those students who participated in the study were instructed to perform the GBL activities every week (please refer to Table 3.5 for the schedule of GBL activities and see Appendix K for sample lesson plan) instead of those written in the module. For the activities that require adult supervision like those that involved manipulation of microscope and/or heating, the researcher asked the students from neighboring households to work collaboratively to complete the GBL exercises and accomplish the GBL activity sheets as a group. In these cases, the researcher asked the assistance of his fellow science teachers from the junior high school to supervise each group as they perform the GBL activity. In some cases, the researcher monitored the students while performing the GBL activity via zoom. Similarly, the researcher uploaded some tutorial videos from YouTube that served as a guide for students while conducting the activity. As culminating activity for the week, students were tasked to present the result of their GBL activity, share their experience, and significant learnings with the class every Friday via Zoom meeting. Moreover, a 10-25-item weekly assessment was given to the students to assess their level of academic performance in each topic.

Table 3.5. Schedule of Activities for Garden-Based Learning

WEEK NO.	DATES	GARDEN-BASED ACTIVITY/LAB REPORT SUBMISSION DATES/OTHERS
0	Dec. 21 Dec. 22-23	• Virtual Meeting with Parents RE: Orientation/ Presentation of the rationale of the research, research procedure and ethical measures of research. • Distribution and retrieval of the accomplished parental and/or participants' consent form
1	Jan. 4-8	• Distribution of Alternative Delivery Mode (ADM) Module in Earth and Life Science and Garden-Based Activity Manual • Read **Module 21:** Unifying Themes in the Study of Life • Perform the following Garden-based Activities **Activity 1**: Crazy Little Thing Called Life **Activity 2:** Investigating Plant Cells
	Jan. 8	**Submission of Outputs/ Discussion via Zoom**
2	Jan. 11-15	• Read **Module 22:** Bioenergetics • Perform the following Garden-based Activities **Activity 3**: You LIGHT up my LEAF **Activity 4:** Evidence of Photosynthesis
	Jan. 15	**Submission of Outputs/ Discussion via Zoom**
3	Jan. 18-22	• Read **Module 23:** Perpetuation of Life • Perform the following Garden-based Activities **Activity 5**: From Seeds to Seedlings **Activity 6:** Propagating Plants Through Stem Cuttings
		Submission of Outputs/ Discussion via Zoom
4	Jan. 25-29	• Read **Module 24:** How Plants Survive • Perform the following Garden-based Activities **Activity 7**: Leaf Morphology **Activity 8:** Monocots versus Dicots
		Submission of Outputs/ Discussion via Zoom
5	Feb. 1-5	• Read **Module 25:** Plant Form and Function • Perform the following Garden-based Activities **Activity 9**: Modified Roots, Stems and Leaves **Activity 10:** Grow Garden in a SNAP
		Submission of Outputs/ Discussion via Zoom
6	Feb. 8-12	• Continue reading **Module 26:** Plant Form and Function • Perform the following Garden-based Activities **Activity 11**: Make Your Own Herbarium **Activity 12:** Floral Variations
		Submission of Outputs/ Discussion via Zoom
7	Feb. 15-19	• Read **Module 27:** Interaction and Interdependence • Perform the following Garden-based Activities **Activity 13**: Energy Flow in the Home Garden **Activity 14:** Relationship Status? It's Biotic-Biotic!
		Submission of Outputs/ Discussion via Zoom
8	Feb. 22-26	• Submission of Reflection Journal •Interview and Focus Group Discussion

A group chat messenger was also created by the researcher and used as a platform for posting reminders/instructions, attending to the students' queries and concerns and uploading learning resources like slide deck presentations. Lastly, all the accomplished learning activity sheets, GBL activity sheets and weekly assessments were retrieved every Friday of the week.

At the end of eight-week period of the implementation of intervention, administration of the Life Science Achievement Test (LSAT) and the three self-report survey questionnaires such as learning engagement survey questionnaire (LESQ)`, and Attitude Towards Biology Scale (ATBS) and Questionnaire on Students' Perception towards Garden-based Learning was done. Group interviews were conducted in order to gain insights about their experience with garden-based learning. The level of mastery of the students from both groups were determined and compared to the DepEd standards to evaluate the effects of garden-based learning strategy.

Data Analysis Procedure

Descriptive statistics were used to analyze the data collected. Measures of central tendency such as mean, frequencies, percentages, and measures of association were computed. The scores obtained by the students on the Weekly Assessment and Life Science Achievement Test were analyzed and compared against the standards used by the National Educational Testing and Research Center (NETRC) to ascertain their level of mastery/achievement. The mastery/achievement level and its descriptive equivalent used in this study was shown in Table 3.6.

Table 3.6. Students' Mastery Level and its Descriptive Equivalent

Percentage	Descriptive Equivalent	Description
96-100	Mastered (M)	Students at this level have demonstrated an exceptional and comprehensive understanding of the subject matter. They consistently perform at an advanced level, with minimal to no errors in their work. They can apply their knowledge creatively and critically to solve complex problems and demonstrate high expertise in the subject.
86-95	Closely Approximating Mastery (CAM)	At this level, a student's performance is very near the level of mastery but may still require some refinement. They highly grasp key concepts and skills and perform well in most tasks. The student is on the cusp of reaching mastery and shows potential for continued growth and perceived improvements.
66-85	Moving Towards Mastery (MTM)	At this level, a student is making progress and actively working to improve their understanding and skills in the subject. The student may demonstrate a basic understanding of foundational concepts but still needs further development to reach higher levels of proficiency. They show potential for growth and are taking steps to enhance their performance.
35-65	Average Mastery (AM)	At this level, a student exhibits a satisfactory understanding of the subject matter. They perform adequately in most tasks and show a moderate level of proficiency. The student may demonstrate competence in standard or routine tasks but may encounter difficulties with more complex or challenging concepts.
15-34	Low Mastery (LM)	At this level, a student has limited understanding and proficiency in the subject. They encounter difficulties in applying knowledge and may require additional support and guidance to improve their performance. The student's work may contain several errors and inconsistencies.
5-14	Very Low Mastery (VLM)	At this level, a student's understanding and skills in the subject are significantly below expectations. They have difficulty grasping fundamental concepts and struggle with basic tasks. The student requires substantial support and intervention to progress.
0-4	Absolutely No Mastery (ANM)	At this level, a student demonstrates a complete lack of understanding and proficiency in the subject. They are unable to perform even the most basic tasks and show no evidence of learning. The student may require intensive remediation and support to address fundamental gaps in their knowledge.

On the other hand, Cramer's V was used to determine the association between the extent of learning engagement and its dimensions and profile variables such as sex and age of the students while the Kendall's Tau Rank Correlation coefficient was employed to determine the association between extent of engagement, academic performance and attitude towards Biology. All statistical analyses were performed using the Statistical Package for Social Science (SPSS) version 17.0.

The qualitative data were analyzed using the coded responses from the written interviews with the respondents. Through the analysis of the coded responses, themes and patterns were identified. Interpretation and analysis were done through the triangulation of interview responses with student narratives or reflections and responses from the self-report survey questionnaire. Pseudonyms were also used for the student responses.

Chapter IV

RESULTS AND DISCUSSIONS

This chapter shows in tabular, graphical and textual presentations of the data gathered from the results of the distributed questionnaire. The specific questions posited in the statement of the problem were presented hereunder based on the data gathered, analyzed and interpreted. This section is a visualization of the findings and results of this study.

Profile of the Participants

The study considered the age and sex of the participants as both variables may determine the appropriateness and effectiveness of garden-based learning.

Age

The students who participated in the study ranged from 16 to 18 years old with ages 16 and 17 having the most numbered participants (i.e., 25 and 38, respectively) (4.1). This is typical in the Philippine basic educational system when it transitioned to the K-12 curriculum. The senior high school (SHS) now consists of students aging 16-18 years old who are streamed into different academic specialization tracks (Macha, Mackie, & Magaziner, 2018). The study of Ducanes and Ocampo (2020) also indicates high participation of students in this age range in senior high school.

Table presents the distribution of the participants by age and sex.

Table 4.1. Distribution of the Participants by Age and Sex

Variables	Frequency	Percentage
Age:	**f**	**%**
16 years old	25	35.71
17 years old	38	54.29
18 years old	7	10.00
Total	**70**	**100**
Sex:		
Male	36	51.43
Female	34	48.57
Total	**70**	**100**

This is critical especially in biodiverse and agricultural-based countries like the Philippines because literature indicates that gardens "can create opportunities for children to discover fresh food, make healthier food choices and become better nourished" [Desmond, Grieshop & Subramaniam, 2004, p. 26] and allow the young generation to "experience deeper understandings of natural systems and become better stewards of the earth" [p.26]. With this age range, the use of GBL could contribute to developing the academic skills and the social, moral, and environmental values of the young generations, which are necessary for protecting and conserving the country's natural resources and enhancing food security. According to Driscoll et al. (2016), garden-based learning will not only allow the growth of important life skills but also nurtures the development of environmental stewardship among the students. Likewise, Phillips (2019) emphasized the importance of fostering a concern for the environment at an early age. He indicated that developing environmental values among the younger generations can help them become more environmentally conscious consumers.

Engaging them in outdoor activities such as gardening will allow them to appreciate the diverse environmental as well as ecological amenities. In the process, they can contribute to creating future changes that are beneficial to the environment (Phillips, 2019). The use of a garden-based learning approach within the age range in this recent study could facilitate the achievement of these outcomes. The responses collected during the interview indicated an increasing awareness among students of the importance of managing the environment. The activities of the approach made them realized their role in caring for the environment as revealed in the following responses:

> *"The concepts that I learn after performing the garden-based activities are plants make their own food during photosynthesis. They also have different shape, size, and venation of leaves because they need to adapt to their environment. We, humans, also need to take care plants to protect since they give us the clean air that we breathe. I hope I can apply all what I have learned in my own simple garden at home."* [**Student 6, 17, Female**]
>
> *"I learned a lot of things about biology through GBL. It includes protecting our environment and the living things on it. I also learned that every creation here on earth has important role to play and we need to take care of them."* [**Student 10, 16, Male**]
>
> *"I learned that plants are not just plants in our garden, it also helps our environment to look even more better."* [**Student 11, 17, Female**]

These realizations can be a good sign of an enhanced awareness of students on their role in environmental protection and management. Given their age range, this could be a good indicator that the approach can produce a cadre of young environmental enthusiasts who can make a change in their community. However, it is suggested that a follow through study that analyzes the retention of these realizations, and the future environment-related decisions and activities of these students can be conducted.

Meanwhile, consistent with several extant research studies on school gardens and students' academic outcomes (e.g. Williams & Dixon, 2013), the study indicates that GBL can potentially motivate even students in this age range to learn biological concepts. Although most of the studies conducted for garden-based programs involved students in the third to fifth grades (Williams & Dixon, 2013), the students' responses in the interview provide a strong indication that GBL can re-kindle students' interest in science in general and in Biology in particular. Students expressed their learning of diverse biological concepts after performing the GBL activities. Below are some examples of their responses when asked about the concepts they learned after performing the garden-based learning activities:

> *"GBL activities has an impact for me to appreciate it. Through this, I learn topics like leaf morphology, photosynthesis, reproduction, interaction and interdependence."* [**Student No. 2, 16, Male**]
>
> *"I got a deep understanding of floral variations, evidence of photosynthesis, plant cells, morphology and many more that made me realize that science is really full of astonishing things that an individual should absorb."* [**Student No. 4, 17, Female**]
>
> *"A lot of knowledge was delivered in garden-based activity, from the easy part of differentiation between living and non-living things, from cells, starch, photosynthesis, flowers, leaf morphology, roots and many more. It clearly taught me about biology even more."* [**Student No. 13, 17, Female**]

As indicated in these responses, students had gained a deeper understanding about plant morphology, photosynthesis, plant reproduction, plant interaction and interdependence, plant cells, and the differing characteristics of living and non-living things after performing the GBL activities. Though only few studies have been conducted on GBL and students' conceptual understanding in the high school, the results could confirm what Gatdula and Gayeta (2019) observed in their study involving the high school students in an integrated school in the Philippines. According to them, students under the garden-based strategy (GBS) had a better understanding and thus performance on lessons about perpetuation of life and plant survival. Likewise, they revealed that the integration of garden-based strategy (GBS) into the teaching of high school's Life Sciences had increased students' performance from average to high level in all the lessons.

In addition, the findings of the study had also supported what Calub et al. (2019) had observed from their School-Plus-Home Garden approach in teaching Grade 7 science. They reported that the students showed perceived improvements in their skills in naming vegetables and classifying food items according to food groups and nutrients. Interestingly, it has also created students' positive outlook on consuming vegetables, gardening, and other science-related courses.

While these findings are promising in producing students with a better outlook on science, gardening, and vegetable consumption, Williams and Dixon (2013) pointed out that the hands-on gardening program could be more effective in higher than lower grade levels. They explained that students at the higher-grade level have more developmentally advanced cognitive skills in science. Therefore, they can better learn, apply, and relate concepts taught during the hands-on gardening program to general science concepts taught at that grade level. They further explained that as the age of the learners increases, their ability to perform complex garden-based activities also increases. Teachers then can use deep science learning through learning activities that older learners find meaningful and fun. Thus, this can explain the responses of the participants when asked about what they learned after performing GBL activities.

Sex

In terms of sex, the participating students were equally distributed. Two sex types were recorded, namely, male and female. Male participants were about 51% (n = 36) while the female participants were 49% (n = 34). This seemingly equal distribution of students by sex is beneficial to the study as responses from both sex types will be equally considered in the analysis. In fact, the interview responses indicated that both male and female students benefited equally from the garden-based learning approach. They reported that the approach had allowed them to learn more about Biology and developed a positive attitude towards this field. For instance, when asked if the approach had affected their perception and attitude towards Biology, both male and female students had positively responded as follows:

> *"In our GBL activity, it greatly affects my attitude or perception towards Biology. It makes me study more about Biology and I found it interesting*." [**Student 1, Male, 16**]
>
> *"Yes, after this garden-based activity, I have appreciated biology even more. I like the way how my eyes and mind became wider as we tackle biology."* [**Student 7, Female, 16**]
>
> *"Well it is absolutely yes, at first it makes me feel hard analyzing biology but when we performed garden-based activities I can freely conclude that biology isn't that hard to understand, with the use of hardworks and dedication to learn it will make easy for you to understand biology."* [**Student 13, Female, 17**]
>
> *"Yes, it changed my perception and attitude towards Biology. Before, I look Biology as a tough subject or a branch of science but then again, this learning technique changed my perception towards Biology. It is not tough just need a deep understanding to appreciate and to love it."* [**Student 2, Male,17**]

The same benefits were observed in the study of Klemmer, Walczek, and Zajicek (2005). They reported that both girls and boys in Grades 3-5 had performed equally on science when taught using the GBL approach. They reported no difference observed in their performance. Pigg, Waliczek and Zajicek (2006) reported the same findings in their study on students' performance in science and math. They reported that sex is not a factor in students' performance in either of the courses. Given these reports and the findings of the study, GBL may be considered as a sex-fair approach in teaching science, or more particularly, biology although other studies have reported otherwise (e.g. Banning, 2015; Waliczek & Zajicek, 1999). For instance, Banning (2015) reported that school garden-based nutrition promotes positive impact on girls than boys based on the post- test results in five determinants of healthy eating behavior such as preference for fruits and vegetables, gardening skills, food systems learning, and perceptions of self-efficacy and social norms regarding fruit and vegetable consumption. Waliczek and Zajicek (1999) had also indicated that girls developed a more positive environmental attitude than boys after participating in the school garden program known as Project GREEN. Nonetheless, these reports highlight the role of GBL in improving both sexes' performance in science and their perception on healthy living and environmental protection.

Extent of Engagement of the Students on Garden-Based Learning

The extent of learning engagement of the students in this study looked at how they interact and participate in all the activities despite of the absence of classroom instruction. The analysis is essential to determine and measure the effective implementation of the approach as well as recognize the quality and quantity of students' participation with their groups to produce the learning outputs. In a way, this analysis considers students' attention, focus and high level of critical thinking under the garden-based learning approach and their interaction and cooperation among their co-members in the group.

Three variables were measured and analyzed in determining students' learning engagement in this study, namely, cognitive engagement, behavioral engagement, and emotional engagement. These three are discussed below.

Cognitive Engagement

As indicated in Table 4.2, the students are highly to very highly engaged in terms of cognition in their academic learning tasks though the overall mean of 3.23 indicates a high extent students' cognitive engagement in the course. Interestingly, the students found the approach useful in connecting what they learned from the course to the real world as such statement has received the highest score among the items measured. To cite, the statement "With the garden-based learning in Biology, I figured out how the information I learned might be useful in the real world" has received the highest computed mean of 3.50 (*very high extent*). It indicates that the students had strongly agreed that the approach allowed them to see the link between the theory or concepts discussed in the class and the outside reality. Furthermore, it may suggest that GBL causes students to have a very high extent of cognitive engagement in the learning process. This observation supports Ratcliffe's (2017) finding where students described the garden-based approach as a learning strategy that allows them to integrate learning in their real-life experiences. It implies that garden-based learning can strengthen the relationship between the theories discussed in the classroom and the real-life situations and/or enhance the real-life experiences of the students because they can now view them vis-à-vis their learning. Klemmer et al. (2005) specifically indicated that students' hands-on experience in school gardens allows them to visualize how they can apply what they learned in the real world. This indicates that the approach was able to motivate students to highly engage their thinking while performing their academic learning tasks (Clarke, 2002[1]) while engaging them in deep thinking that led them to connect their learning to their reality. Although Bircan and Sungur (2016[2]) reported that cognitive engagement did not predict the science achievement of students in their study, the very high extent of students' cognitive engagement in figuring out how their learning can be useful in the real world may foster personal and social development, which may increase their involvement in any civic activities.

In addition, the approach helped the students see the interconnection and integration of all the knowledge they learned in the course as well as allowed them to create their own examples. With a mean of 3.31 (*very high extent*), students agreed to the statements "I understand how things I learn in school fit together with each other" and "I learn how to give my own examples." It indicates a very high extent of students' cognitive engagement. Ratcliffe (2017) emphasized that garden-based learning as an instructional strategy allows students to combine what they learned, make sense of them, and then integrate them into experiences relevant to their lives. It also accords them the opportunity to co-create new knowledge, and thereby maximizing their learning engagement in the course. Heinrichs (2016) observed similar findings in her study involving the kindergarten students, their parents, and their community.

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[1] https://www.researchgate.net/publication/334891109_Student's_Cognitive_Engagement_in_Learning_Process

[2] https://files.eric.ed.gov/fulltext/EJ1131144.pdf

Table 4.2. Extent of Engagement of the Students on Garden-Based Learning in Terms of Cognitive Engagement (N=70)

Items With the garden-based learning in Biology…	Mean	Descriptive Interpretation
I figure out how the information I learned might be useful in the real world.	3.50	Very High Extent
I understand how things I learn in school fit together with each other.	3.31	High Extent
I learn how to give my own examples.	3.31	High Extent
I pay attention to my teacher.	3.30	High Extent
I associate them with what I learnt in other classes about the same or similar things.	3.27	High Extent
I connect what I am learning with my own experience.	3.26	High Extent
I realize my passion/interest in science.	3.26	High Extent
I think through topics and decide what I'm supposed to learn from them, rather than studying topics by just reading them over	3.23	High Extent
I master skills and acquire new knowledge.	3.21	High Extent
I understand the material better by relating it to things I already know.	3.20	High Extent
I learn to use simple drawings, concept maps or tables to help me organize the course material.	3.20	High Extent
I focus on studying easy parts when the topic is hard.	3.17	High Extent
I analyze the similarities and differences between the things I am learning and things that I already know	3.16	High Extent
It increases my curiosity to discover more about my environment.	3.16	High Extent
I know that I do better when answers are given to me.	3.09	High Extent
I know how to put the new information into my own words.	3.09	High Extent
Overall Mean	**3.23**	**High Extent**

Note: 1.00- 1.49= Very Low Extent, 1.50-2.49= Low Extent, 2.50- 3.49= High Extent, 3.50- 4.00= Very High Extent

She reported that children learned maximally both at school and at home using the garden-based learning approach. She further indicated that the approach had allowed students to use their learning in exploring the real world. According to her, the "parents were impressed with the students' attention to details when exploring outside" (p. 20).

The approach has also reinforced students' experience and learning from their other courses with their knowledge gained in the course. This is critical because this would broaden their perspective in biology, deepen their understanding of the concepts discussed in the course, and create meaning of their prior experience and knowledge. This is indicated by the mean of the following statements:

> *"I associate them with what I learnt in other classes about the same or similar things."* (mean = 3.27, very high extent).
> *"I connect what I am learning with my own experience." (*mean = 3.27, moderately extent*)*
> *"I understand the material better by relating it to things I already know."* (mean = 3.20, high extent)
> *"I analyze the similarities and differences between the things I am learning and things that I already know."* (mean = 3.16, high extent)

Using the lens of constructivism, GBL was able to help students actively construct knowledge by connecting their learning in the course with their prior knowledge and own reality or experience. The interview responses of the students corroborated these results. Below are some of the responses noted during the interview:

> "*Whenever we had to perform an experiment or activity to explain why a specific phenomenon exists, it never failed to make me understand each topic as realizations began to emerge throughout the process, hence it gave me a better knowledge of a certain matter*." [**Student 3, Male, 16**]

"…..garden-based activity helps me to better understand the topics discussed in my ADM Module. In the way that I can apply it to my everyday life" [**Student 6, Female, 17**]

"I got a deep understanding of floral variations, evidences of photosynthesis, plant cells, morphology and many more that made me realize that science is really full of astonishing things that an individual should absorb". [**Student 4, Female, 16**]

"…I understand the topics that discussed in ADM module, it helps me to improve my learnings in garden, it also helps me to improve my knowledge about biology and skills in gardening". [**Student 10, Male, 16**]

"As a whole, garden-based activity really helped a lot it emphasizes the idea about biology. Through performing different garden-based activity it makes easy to fully understand and analyze the topic, the idea of having garden-based activity makes our mind more knowledgeable when it comes to biology". [**Student 13, Female, 17**]

As indicated in these responses, GBL activities were able to; (a) give students a better knowledge of certain matter; (b) provide students a better understanding of concepts and a knowledge that they can apply in their everyday life; (c) lead students to realize that science is filled with several astonishing things; and (d) improve students' knowledge on gardening and biology. GBL was able to bring students to a certain level of cognitive challenge that helps them develop a deeper understanding of the concepts related to the activity. Paulsen and McCormick (2020)[3] indicated this when they concluded that deeper understanding of concepts cannot simply occur without a cognitive challenge. This cognitive challenge motivates students to participate in the application, analysis, synthesis or evaluation of information. This differentiates garden-based learning from the conventional lecture-based learning where students are more passive and mostly, do not partake in the teaching-learning

[3] http://dspace.khazar.org/bitstream/20.500.12323/4406/1/reassessing%20disparities%20in%20online%20learner%20student.pdf

process. In contrast, students in GBL are highly engaged in learning tasks that require them to actively partake in cognitively challenging problems (Collaço, 2017)[4].

Interestingly, the approach has motivated the students to explore ways to address their learning difficulties. They agreed on statements like "*I learn to use simple drawings, concept maps or tables to help me organize the course material*" and "*I focus on studying easy parts when the topic is hard*" with means of 3.20 and 3.17, respectively. Both values indicate a high extent of students' engagement in the learning process, and further indicate that GBL was able to motivate students to develop their conceptual skills. Understanding better complex scenarios and finding creative solutions for them are expressions of conceptual skills (Indeed Editorial Team (2021)[5]. From an education perspective, such skills are important because students are able to approach diverse ways in any complicated learning situations, which in this case are the learning activities during this time of pandemic. As indicated above, students learned to cope with their difficulties by using simple visuals or finding the easy parts of the lesson when it becomes more difficult.

In addition, they reported that they overcame the difficulties in performing their tasks by following the instructions or discussing them with their group mates before they started the activity. These strategies were able to help them successfully performed the activities. Their success had given them satisfaction and motivation to learn more. These are indicated in the following responses:

> *"I think the specific part that help me better to understand the topics is when we, groupmates, brainstorm and analyze the procedure before we*

[4] https://articlegateway.com/index.php/JHETP/article/view/1545/1475
[5] https://www.indeed.com/career-advice/career-development/conceptual-skills

perform it. Also, we exchange ideas when we answer the questions and report our observations." [**Student 10, Female, 18**]

"Doing GBA is seriously exciting and fun though we did also encounter some challenges and difficulties that is why we are really happy after we successfully performed our activity." [**Student 3, Male, 16**]

"Well, it is quite hard and challenging but I really enjoy it; the mere fact that it gives satisfaction and also it makes us more knowledgeable when it comes to biology. We did those activities right and we properly analyzed it, so it may be hard but following the steps makes it easy." [**Student 13, Female, 16**]

Indeed, garden-based learning helped the students to enhance their cognitive skills and acquired more knowledge to ease the difficulty in learning Biology. It enabled them to gain visionary perspective that through garden-based learning, students establish their interest in doing their activities despite of the threat of pandemic. From teachers' perspective, it would give them an idea on how to develop more informative and challenging activities to be incorporated in the development of supplemental learning materials. By doing so, students shall continuously learn Biology independently, yet more engaging considering that garden-based learning activities may possibly associated the parental involvement.

Emotional Engagement

Table 4.3 shows the results of the students' emotional engagement in the learning process using the garden-based learning approach. As indicated in the table, the overall extent of students' emotional engagement in the learning process is high with an overall mean of 3.09 although the individual assessment shows a high to very high extent of engagement.

Table 4.3. Extent of Engagement of the Students on Garden-Based Learning in Terms of Emotional Engagement (N=70)

Items	Mean	Interpretation
With the garden-based learning in Biology…		
I do not feel irritated and uncomfortable in class.	3.80	Very High Extent
I enjoy gardening activities.	3.54	Very High Extent
I feel accomplished whenever I understand the lesson.	3.46	High Extent
I enjoy discovering and learning new things	3.43	High Extent
I am excited about the next day's lesson	3.33	High Extent
I feel comfortable asking for help from my classmates or teacher when I am having trouble learning science topics.	3.17	High Extent
I feel at ease gaining skills and knowledge than the grade I receive.	3.06	High Extent
I feel motivated to finish reading my ADM module even if it is dull and uninteresting.	3.06	High Extent
I got bored doing my modules.	3.03	High Extent
I am very interested in learning.	2.73	High Extent
I feel motivated even if I do not like what I am doing.	2.67	High Extent
I feel nervous when I am in class.	2.56	High Extent
I easily get frustrated when I get a low score in tests, activities, or experiments.	2.01	Low Extent
Overall Mean	**3.06**	**High Extent**

Note: 1.00- 1.49= Very Low Extent, 1.50-2.49= Low Extent, 2.50- 3.49= High Extent, 3.50- 4.00= Very High Extent

Among the highest rated statements are the following:

"I do not feel irritated and uncomfortable in class." [mean = 3.80]

“I enjoy gardening activities.” [mean = 3.54]

“I feel accomplished whenever I understand the lesson.” [mean = 3.46]

“I enjoy discovering and learning new things.” [mean = 3.43]

“*I feel that there is a need to continue working even the tasks are uninteresting*.” [mean = 3.39]

These indicate that (a) students felt more comfortable in learning with the approach; (b) learning has become more enjoyable with discovering and learning new things through the gardening activities; and (c) students are more satisfied with the learning process especially when they successfully performed their activities even if they are uninteresting. These findings had corroborated with what Desmond et al[6]. (2004) had observed about the impacts of garden-based learning in the basic education. According to them, GBL captures students’ interest and energizes their learning. In addition, Skinner et al. (2012)[7] concluded that GBL can awaken students' interests in science and sustainability and enhance their motivation and achievement in school. Both qualitative and quantitative studies (e.g. Brynjegard, 2001[8]; Fusco, 2001[9]; Pranis, 2004[10]) had consistently reported the impacts of GBL in enhancing students’ delight, enthusiasm, and vigorous participation in gardening activities, and increasing levels of students’ interest, motivation, and engagement.

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[6] http://www.fao.org/3/aj462e/aj462e.pdf

[7] https://www.researchgate.net/publication/311643817_Does_Engagement_in_Garden-based_Activities_Predict_Changes_over_the_School_Year_in_Science_Learning_in_the_Garden_and_Academic_Achievement_in_At-Risk_Middle_School_Students

[8] https://eric.ed.gov/?id=ED452085

[9] Fusco, D. (2001). Creating relevant science through urban planning and gardening. Journal of Research in Science Teaching, 38, 860-877.

[10] Pranis, E. (2004). School gardens measure up. Retrieved from National Gardening Association website: http://garden.org/articles/articles.php?q=show&id-952.

In addition, GBL had enhanced students' enjoyment in learning especially when they discover or learn new things or engage in the gardening activities. One student has commented in the interview as follows: "*When I am performing the activity, I enjoy a lot I discovered a lot of things it was fun and exciting because it's been a year since I do an activity like this* [Student 10, Male, 16]." Such very high extent of emotional engagement in learning could be due to their interactions with their classmates and their ability to connect with nature through gardening activities. Students may have developed a strong sense of camaraderie with their group mates and thus, perceived the activities as not just for learning purposes but also as a means to connect with their classmates and nature. As a form of experiential learning, GBL has allowed to develop trusting relationships among the students while making them comfortable with emotional expression (Institute for Experiential Learning, 2021)[11]. When asked about the specific part of the approach that helped them understand better the concepts, one student replied "*When we're doing group activities with our classmates in our garden. We really enjoyed and had fun at the same time learn a lot* [Student 11, Female, 17]." Ratcliffe (2017) reported that garden-based learning activities and interactions increased students' self-enjoyment. Hernik and Jaworska (2018)[12] considered this as extremely important because self-enjoyment and happiness can positively affect learning, memory, and social behavior especially in a learning community. Enjoyment creates a sense of balanced life, which in turn, leads to a feeling of being valued and a necessary part of a group. Developing both emotions can evoke positive attitude towards learning (Hernik & Jaworska, 2018).

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[11] https://experientiallearninginstitute.org/resources/what-is-experiential-learning/

[12] https://www.researchgate.net/publication/323897499_THE_EFFECT_OF_ENJOYMENT_ON_LEARNING

In addition, such a degree of emotional engagement can be due to their increased autonomy in the garden as opposed to a more or less controlled or regulated interactions inside a conventional classroom. Skinner et al. (2012) reported that the greater students' autonomy in the garden had increased their intrinsic motivation to learn. Ratcliffe (2017) also emphasized that garden-based learning increased students' motivation by learning independently and encourage each students' potential. This could also be the reason why the statement "*I feel accomplished whenever I understand the lesson"* had a relatively higher mean. Since motivation leads the students to do their tasks (Ryan & Deci, 2000[13]), successfully performing their tasks, which in this case are understanding their lessons through the garden-based learning activities will give them self-satisfaction. In fact, Ryan and Deci (2000) emphasized that intrinsic motivation can lead students to produce high-quality learning and develop creativity; hence, students can be satisfied with the outcomes of their work despite the challenges or difficulties they encountered in the performance of the tasks. Students indicated these in their responses to the interview questions as exemplified by this one response: *"The part of the activity I enjoyed the most is seeing the results of our experiment and seeing that our efforts were worth it. Doing experimental activities were not easy for us but we made sure to do our best in performing our task efficiently and witnessing how our hardships paid off truly made me feel at ease* [Student 4, Female, 16]*"*.

In addition, such motivation can lead students to perform their tasks even if they found them uninteresting. This can also be the reason why the statement "*I feel that there is a need to continue working even the tasks are uninteresting*" received a

[13] https://selfdeterminationtheory.org/SDT/documents/2000_RyanDeci_IntExtDefs.pdf

relatively high mean (3.39), which indicates a very high extent of engagement. This is also supported with the relatively high extent of students' engagement in learning their ADM modules even if it is dull and uninteresting (mean = 3.06, high extent) as well as continue doing their tasks even if they do not like them (mean = 2.67, high extent).

Interestingly, the statement "*With the garden-based learning in Biology, I easily get frustrated when I get a low score in tests, activities, or experiments*" received the lowest mean (2.01), which indicates a low extent of students' emotional engagement. This result indicates that students exposed to GBL approach do not only engage in learning for the sake of getting good grades but for the sake of learning and becoming a better student. In fact, one student revealed in the interview that "*It was fun and enjoyable because with these experiences it molds us to be a better student* [Student 7, Female, 16]." In addition, students agreed on statements that "*I am very interested in learning*" (mean = 2.73) and "*I feel at ease gaining skills and knowledge than the grade I receive*" (mean = 3.06). The computed means for these statements indicates high extent of emotional engagement.

Moreover, the results indicate that GBL approach can address the emotional impacts of students' low performance. As indicated in Table 4.3, students have very high engagement for self-motivation and enjoyment; thus, they may never be frustrated with the outcomes of their engagements. What matters to them are the new discovery and learning with the garden-based activities they do as well as their transformation as a student as this one student had commented during the interview *"It is also satisfying on our part because we were able to complete it while still having fun and learning new things as a result of everything, we did that educated us and make us proud* [Student 4, Female, 16]." Since GBL is more of exploring, it has developed students' critical thinking skills and sense of ownership to become independent learners (Boss, 2001). This explained why students are learning in a less or no frustrating way and engaging themselves in a more exciting and enjoyable learning experiences. Thus, students felt the worth of the garden-based activities despite difficulties. One student reported that *"…after all those difficulties, it was all worth it because through GBL, I was able to understand topics like photosynthesis, characteristics of living things, leaf variations, and parts of the flower."* In fact, even if they felt nervous performing the activities (see Table 4.3), it did not hinder them to explore and learn new things. Rather, they felt they learned more about science and grew like the plants they observed in their learning activities just as this student had reported: *"I really enjoyed all the activities. I can't believe that learning science would be that fun. Like plants, I feel I am growing and more growing after every lesson that our subject teacher teaches us [Student 6]."* This finding supports the claims of other researchers that through garden-based activities, students show more positive attitudes towards science. In fact, several studies (e.g. Waliczek, 2001; Murphy, 2003; Dirks & Orvis, 2005) indicated that school garden programs can increase interest and excitement for learning science. When given an opportunity to engage in high-quality science learning activities, students will participate enthusiastically and do well in the gardens and science class (Williams et al., 2018).

As indicated in the interview responses cited above, students affirmed that they were able to gain positive emotion throughout their experimental activities. In the traditional classroom setting, they feel uncomfortable and irritated but with garden-based activities specifically home gardening, they felt the excitement and enjoyment of learning. In the same sense, it enabled them to manage their time, patience, collaboration, teamwork, communication, understanding, leadership, and other skills that have been developed through the garden-based learning activities. Since it was a group activity, students had the opportunity to engage in in-depth discourses with their group mates, allowing them to develop positive attitudes towards learning, science, and Biology. These are indicated in the following interview responses:

> *"Because of GBL, my perception towards Biology changed. Back then, I find Biology as a boring subject. But after performing all the experimental activities, my perception towards Biology changed in many ways. I love and I really enjoyed studying Biology."* [Student 3, Male, 16]

> *"Kasi dati takot ako sa science kasi madami sauluhin tapos ang hihirap pa ng exam. Ngayon po eh hindi na kasi masaya po kami sa ginagawa po tapos mas madali namin matandaan ang mga pinagaralan."* [Before, I used to be afraid of science because there is a lot to memorize and then the exam will be difficult. Now it's not because we're happy with what we're doing and then it's easier for us to remember what we've learned][Student 5, Male, 17]

> *"I have learned the concept of having a virtue of patience, as these activities need your time and patience as we observe and wait for the results of an activity."* [Student 7]

> *"I think the specific part that help me better to understand the topics is when we, groupmates, brainstorm and analyzing the procedure before we perform it. Also, we exchange ideas when we answer the questions and report our observations."* [Student 10]

The garden-based learning through home-based gardening provides emotional access to the scientific content of biology lessons and strengthens social learning. This activity enabled the students to be more responsible for their plant in a span of time specified (Pollin &Furst, 2013). Such implication may be enough to consider the inclusion of a garden-based learning approach in the curriculum. In so doing, students may become more engaging and active in all activities in a biology class. At the same time, it would have enhanced students' attitudes, values beliefs, and self-perceptions towards Biology.

Behavioral Engagement

As indicated in Table, the students showed a high extent (mean = 3.29) of behavioral engagement with GBL. The statement *"With the garden-based learning in Biology, I strategize to ensure that I learn the subject well"* received the highest mean (3.53), which indicates a very high extent of engagement. The result indicates that students had found ways on how to deal with the rigors in their study given the approach. Like any other teaching approach, GBL had its own challenges and rigors, which the students must overcome.

Table 4.4. Extent of Students' Behavioral Engagement in Garden-Based Learning (N=70)

Items **With the garden-based learning in Biology…**	**Mean**	**Interpretation**
I strategize to ensure that I learn the subject well.	3.53	Very High Extent
I got distracted and miss important points during discussions.	3.51	Very High Extent
I put enough effort into learning the life science concepts and theories	3.46	High Extent
When learning things in this subject, I often try to understand the material better by relating it to things I already know.	3.43	High Extent
I easily give up when I don't understand my lessons.	3.39	High Extent
I work hard to do well in class even if I don't like what we are doing.	3.39	High Extent
I find time to review my notes or readings before the exam.	3.36	High Extent
I am determined to work with difficult homework.	3.34	High Extent
I set goals for myself to direct my activities in each study period.	3.34	High Extent
I finish my learning tasks efficiently.	3.33	High Extent
I prepare well for my tests/ experiments.	3.30	High Extent

Items With the garden-based learning in Biology…	Mean	Interpretation
I participate actively in the discussion.	3.29	High Extent
I try to change the way I study to fit the course requirements and the teacher's teaching style.	3.23	High Extent
I make sure that I keep up with the weekly readings and assignments for the subject.	3.21	High Extent
I prioritize working with my tasks than playing Mobile Legends, browsing my social media accounts, etc.	3.20	High Extent
I use an electronic medium (Facebook, group chat, Internet, instant messaging, etc.) to discuss or complete an assignment.	3.20	High Extent
I inquisitively ask questions to clarify important points of the lesson.	3.16	High Extent
I have time to discuss ideas from the readings or classes with others outside of class (students, family members, co-workers, etc.)	3.06	High Extent
I volunteer to tutor my classmates.	2.77	High Extent
Overall Mean	**3.29**	**High Extent**

Note: 1.00- 1.49= Very Low Extent, 1.50-2.49= Low Extent, 2.50- 3.49= High Extent, 3.50- 4.00= Very High Extent

Students reported these challenges during the interview as follows:

"…laziness, time management and trial and error are the challenges we encountered because at some point, we need to repeat our activity three times because we failed. So, I think that is the only conflict we experience weekly." [Student 2, Male, 17]

"*Ang mga hamon na aking kinaharap ay ang kakulangan sa materyales sa mga isinasagawang proyekto, paglalaan ng oras pero ngayon ay medyo gamay ko na ang paghahati ng aking oras para sa bawat asignatura na aking ginagawa, mga kagrupo na hindi ako pinapansin at hindi masyado nakiki-cooperate tuwing may groupings*." [Student 8, Female, 18]

"*We experienced the time wherein we have no flowers to find and also when we have those flowers it was definitely hard for us to identify their names same to those leaf and for sometimes, we failed to performed the activity properly*." [Student 13, Female, 17]

As implied in these interview responses, students have encountered difficulties in independently performing the learning activities. Their difficulties ranged from creating time for the activities, developing the right attitude towards them, collaborating with groupmates, and finding resources. One student also reported, "…*we all know that there is still a pandemic so it is difficult to conduct the activity with our groupmates so we just communicate through messenger*" [Student 1, Male, 18].

However, despite experiencing these challenges, they could perform and accomplish the assigned tasks. Truly, creating strategies to overcome these challenges could have been the reason for their success. Students strategized in a way that they were learning independently using the approach, especially since GBL involved critical thinking, problem-solving, and reasoning. As Miller (2007) had indicated, performing the activities in a GBL approach gives students the opportunity to strategize their learning process and create a way to connect physically, intellectually, emotionally, and spiritually with nature. It also opens to them an opportunity to better internalize their learning. Student 1 emphasized the need to communicate with his groupmates through a messenger apps so as to perform their activities given the difficulty for physical meeting due to the pandemic. Student 13 also indicated that they could overcome the hardships they experienced by following the step-wise instruction of the activities. To wit: "*We did those activities right and we properly analyzed it, so it may be hard but following the steps makes it easy.*" Other strategies adopted by the students include: (a) having a dedication and focus so that the concepts are well understood; (b) having patient; (c) developing eagerness to perform the tasks; (d) discussing and internalizing the instruction as a group; and (e) being resourceful. These are all indicated in the following interview responses and could also be why such a statement in Table 4.5 had the highest mean.

> "*It [GBL] helps me a lot specially to those activities that need deep understanding. Now that we are in the new normal learning system, it is very essential because it is hands-on, and it requires effort, dedication and focus so that the concepts are well understood*." [Student 2, Male, 17]

> "*I have learned the concept of having a virtue of patience, as these activities need your time and patience as we observe and wait for the results of an activity*." [Student 7, Female, 16]

> "*I do really like the part where we finally saw the results of our experiments, because in most situations, we even failed to do it right and I like how our eagerness to make it precise or find out what's wrong with our activities arouses us to investigate. So, when we did it accurately it feels like everything was paid off*." [Student 4, Female, 16]

> "*I think the specific part that help me better to understand the topics is when we, groupmates, brainstorm and analyzing the procedure before we perform it. Also, we exchange ideas when we answer the questions and report our observations*." [Student 10, Male, 16]

> "*…hindi basta-basta ang pagtatanim dumidepende pa ito sa uri ng binhi na itatanim mo at sa lugar na pagtataniman mo, buti na lamang ay may mataba kaming lupa at ako ay ginabayan din ng aking ina sa pagtatanim.*" [planting is not easy, it depends on the type of seed you plant and the place you plant, fortunately we have fertile soil and my mother also guided me in planting] [Student 8, Male, 16]

Meanwhile, students got distracted and missed points during the discussions as indicated in Table 4.5. The students' responses show a very high extent of behavioral engagement about "I got distracted and miss important points during discussions" (mean = 3.51). Students' ability for comprehension and the retention rates could have fluctuated because of the distractions they experienced while being at a distance from the teacher. Among the distractions being cited by the students are as follows: (a) friends who invited them to play mobile games (*Student 10*); (b) bad weather (*Student 7*); (c) lack of materials for the project (*Student 8, Student 11, and Student 12*); (d) time mismanagement (*Student 8*); and (e) low storage capacity of gadgets for their activities (*Student 4*). Though GBL is supposed to enhance their knowledge retention due to its experiential and exploratory nature of learning, students have indicated otherwise because of these distractions. As Subramaniam (2002) had indicated through a study done by the Bethel Learning Institute, about 95% of the information is supposed to be retained when the learning of the students is being applied or about 75% will be retained if learning is by doing. But because of the distractions cited by the students, it is possible that their retention was affected and consequently, they missed important points in the process. This could possibly be the reason why the statement "I got distracted and miss important points during discussions" got the second highest mean. The result needs to be considered in implementing GBL via distance learning mode or if students will work on their tasks independently. The distractions should be addressed to maximize the experiential learning of the students through GBL. Otherwise, the overall goal of GBL could be compromised in case these distractions will remain unabated. In addition, it can be gleaned that distractions seemed to be dependent on the location of the students. Different students experience different distractions. Thus, it is important that the measures planned to address these distractions should consider the learning context of the students.

Interestingly, the students highly agreed on the statement "With the garden-based learning in Biology, I put enough effort into learning the life science concepts and theories". In fact, it has obtained the third highest mean (3.46) among the statements considered in the behavioral learning engagement of the students (Table 4.5). Haury & Rillero (1994) explained that students learn to put enough effort into their learning when they are given the opportunity to actively participate in the teaching-learning process, i.e., they have gone through in-depth investigations and actual experimentations in the class. As a result, they will draw meaning and understanding for their learning from their actual and experimental engagements.

Meanwhile, a high extent of learning engagement with the garden-based learning in Biology which highlighted that student-respondents inquisitively ask questions to clarify important points of the lesson, and they have time to discuss ideas from the readings or classes with others outside of class (students, family members, co-workers, etc.), with means of 3.16 and 3.06, respectively. The study by Swank and Swank (2013) designed a complex counseling program that would address several challenges faced in academic, career, social, moral, and personal development of the students. Nonetheless, school counselors suggested integrating natural environment like garden-based learning to show perceived improvements student performance. Further, the same study stressed that students achieve its development and discuss additional insights through collaboration with some stakeholders such as teachers, peers, family and the community.

Furthermore, the said group of respondents responded moderately extent of learning engagement to the garden-based learning in Biology wherein they volunteer themselves to tutor their classmates which got the least mean of 2.77. This was supported by the Bethel Learning Institute study in which 90% of learning took place when students shared and divulged information that they acquired to other students. In that way, a learner has an initiative to tutor their classmates since the level of understanding differs and varies among students.

Students affirm they put sufficient effort into learning concepts and theories in life science; well prepared, determined and efficiently working to finish the learning tasks, activities and experiments alike. Adhere on time management to do all the necessary things like reviewing past lessons, reading in advance, discussing ideas to classmates and volunteering to tutor classmates rather than exhausting time in the use of electronic media despite the prevalence of online gaming, to come to class prepared and excited. Students also work hard to change to fit for the teacher's teaching style and even come up with respective strategies to ensure learning well from the subject.

Based on the students' responses in the interview, home gardening activity gave an opportunity to the students to strategize especially when resources and needed materials were not available. Also, they enabled to communicate with their groupmates and to their respective families since the activity was about innovative planting with no soil use. In addition, they exerted lots of effort in doing home gardening and experimental activity to avoid failure because they will start the process all over again if it happened. Some students' responses highlighted that the activity increased their family bonding and able to help overcome emotional distresses.

"I strategize to ensure that I learn the subject well (mean=3.53, very high extent)".

[Student 3] *"Of course, there are challenges and difficulties that we have encountered. Like when we don't know how to do the activity, but we were able to surpass that because our teacher keeps on explaining the topic and telling us on how to do the activity".*

[Student 4] *"I do really like the part where we finally saw the results of our experiments, because in most situations, we even failed to do it right and I like how our eagerness to make it precise or find out what's wrong with our activities arouses us to investigate. So, when we did it accurately it feels like everything was paid off".* In addition, "*If there is any, it would be the documentation because there are instances that I need someone film me but no one's available or my phone doesn't have enough storage for photos and videos. However, I was still able to deal with it and had fun".*

[Student 7] *"One of the challenges I have encountered is the weather, throughout the journey, the weather isn't always good. Fortunately, we have figured it out and was still able to work on it well".*

[Student 11] *"The challenges that I have encountered while conducting our activities is when we can't find that exact plants/flowers that we needed in the particular activity".*

[Student 13] *"Ahmm for some instances, we experienced the time wherein we have no flowers to find and also when we have those flowers it was definitely hard for us to identify their names same to those leaf and for sometimes, we failed to performed the activity properly".*

"I got distracted and miss important points during discussions (mean=3.51, very high extent)".

[Student 1] *"Challenges can't be avoided. We experienced some difficulties during the conduct of our activity like we experience many trials and also we all know that there is still a pandemic so it is difficult to conduct the activity with our groupmates so we just communicate through messenger".*

[Student 10] *"The challenges that I've encounter is when I got distracted by my friends and they invited me to play mobile games".*

The current pandemic became a determinant that hampers students' opportunity to cooperate with their groupmates. Considering the many interventions at home and destractions, students became less motivated and discouraged on the difficulties that have been experienced and diverted their time and attention to other non-academic related activities.

"I participate actively in the discussion (mean=3.29, high extent)".

[Student 2] *"In my opinion, laziness, time management and trial and error are the challenges we encountered because at some point, we need to repeat our activity three times because we failed. So, I think that is the only conflict we experience weekly".*

[Student 6] *"The challenges that I have encountered, while conducting the assigned activities per week is when we need to cooperate us as one or as a group but it is hard as the situation right now during pandemic is still exist".*

These responses have been the challenges that some students encountered when it comes to cooperation since students were unable to meet with their groupmates regularly and they just communicated through chat. Undoubtedly, these responses were just appropriate considering the existence of current pandemic. Notwithstanding, it would have different or opposite results in a normal situation with no face-to-face restrictions.

It was noteworthy to say that garden-based learning conveyed positive implications to all the students specifically when it comes to the behavioral engagement towards Biology. It contributed much in framing the alternative educational curriculum that would integrate garden-based learning to boost students' positive attributes and transform negative connotations of Biology into a positive attitude. According to Ozer (2008), school gardening promoting students' achievement, motivation to learn, psychosocial development (such as self-esteem, responsibility, and etc.), behavioral engagement, teamwork, and cooperation with groupmates (Pranis, 2004). A similar effect in home-based gardening to which positivity must be accentuated since students' tendency to become bored, discouraged, and hopeless was relatively high due to isolation brought about by COVID-19 pandemic.

Table 4.5. Summary of the Extent of Engagement of the Students on Garden-Based Learning

Variables	Overall Mean	Interpretation
Cognitive Engagement	3.23	High Extent
Emotional Engagement	3.10	High Extent
Behavioral Engagement	3.29	High Extent
General Mean	**3.21**	**High Extent**

Note: 1.00- 1.49= Very Low Extent, 1.50-2.49= Low Extent, 2.50- 3.49= High Extent, 3.50- 4.00= Very High Extent

Summarizing the responses of the student-respondents on the extent of their engagement in Garden-Based Learning, it was found out that behavioral engagement made the highest overall mean of 3.29 followed by cognitive which has an overall mean of 3.23. Meanwhile, emotional engagement got the least overall mean of 3.10. Several authors connoted that emotions were associated with garden-based learning. In fact, Miller (2007) implied that environment helps student to connect emotionally; Skinner et al. (2008) engaged emotion to promote important behavior; Swank and Swank (2013) emphasized that outdoor activities that directly involve the natural environment improve emotional learning; and Block et al. (2012) connoted that garden-based learning remarkably affect emotional growth. Moreover, garden-based learning encompassed cognitive engagement with the students. Ratcliffe et al. (2017) revealed that garden-based learning experiences may affect students' cognitive skills due to its exploratory and experimental in nature; Miller (2007) denoted that experiential approach of garden-based learning promotes student to connect internally; and gained intellectual benefits through students' active immersion in garden-based learning which developed garden programs and gardening projects. Finally, this educational method includes behavioral engagement that mold students' moral aspect in life. Pe'er et. al. (2007) concerned with the attitudes and values formation to motivate essential knowledge in environmental behavior; Swank and Swank (2013) specified that behaviors were conducive to learning in a garden-based learning and Ratcliffe et. al. (2017) ascertained that the effects of school garden experiences were attitudes and behaviors associated with vegetable consumption and enhanced social and moral development as well. Generally, the general mean of 3.21, including all three variables, was agreed upon by the student-respondents associated with garden-based learning. This was supported from the above-mentioned authors and writers who conducted relevant studies pertaining to garden-based learning and its learning experiences among the grade 11 students.

Level of Performance of Students in Life Science Achievement Test

The level of performance of students both on the weekly assessment (Table 4.6) and on the life science achievement test (Table 4.7) were examined and compared to evaluate the impact of garden-based learning to the academic performance of students. As indicated in Table 4.6, the level of performance in the weekly assessment test based on the score interpretation suggested by the National Educational Testing and Research Center (NETRC) showed that 46 or 65.71% of the student participants were in the range of 35-65% rating with a descriptive equivalent of Average Mastery (AM). This suggests that most participants demonstrated only the fundamental knowledge and skills in life science, mostly learned during their junior high school science subjects. Interestingly, it can also be gleaned from the table that more than 30% of the students obtained a percentage rating score ranging from Moving Towards Mastery (MTM) and Closely Approximating Mastery (CAM).

Table 4.6. Students' Level of Performance on the Weekly Assessment Test

RANGE	FREQUENCY	PERCENTAGE	DESCRIPTIVE EQUIVALENT
96-100	0	0	Mastered (M)
86-95	3	4.28	Closely Approximating Mastery (CAM)
66-85	19	27.14	Moving Towards Mastery (MTM)
35-65	46	65.71	Average Mastery (AM)
16-34	2	2.86	Low Mastery (LM)
5-15	0	0	Very Low Mastery (VLM)
0-4	0	0	Absolutely No Mastery (ANM)
TOTAL	**70**	**100**	
OVERALL MEAN		**59.34**	**AVERAGE MASTERY**

This implies that only twenty-two (22) students have already acquired or developed the fundamental knowledge, skills, and core understanding required by the subject. Since majority of these students were enrolled in the academic track, it is expected of them that they are more responsible and developed a more effective studying habits when they were in the junior high school. Their ability to integrate what they have learned from their science subjects to the real-life experiences, connect the past lessons to the present ones and appreciate its practical application may also helped them remember and recall easily during exam.

In addition, their teacher probably employed an effective teaching strategy that cultivated the interest of the students towards learning science and developed positive attitude towards the subject, thus performed well in the exam. This is possible because the Department of Education (DepEd) teachers were encouraged to utilize varied teaching strategies to cater to diverse types of learners. In fact, two objectives in the Results-based Performance Management System (RPMS) Manual for Proficient Teachers (Teacher I-III) used by the department were related to this as basis for evaluating teachers' performance. These are objective 3 "*Applied a range of teaching strategies to develop critical and creative thinking, as well as other higher-order thinking skills."* And objective 6 "*Used differentiated, developmentally appropriate learning experiences to address learners' sex, needs, strengths, interests*". This is also in accordance with Piaget's Cognitive Development Theory, in which he posited that a constructivist classroom provides students multiple activities that will challenge them to accept individual differences, discover new ideas, and construct their own knowledge (Bation & Sabaldana, 2018).

Remarkably, two (2) students were identified at the Low Mastery (LM) level. This implies that the conventional teaching method employed during their junior high school years had not developed the students' conceptual knowledge in Biology. Commonly, teachers employed a teacher-centered learning approach creating less opportunity for the students to interact and raise questions for clarifications about the concepts discussed during study sessions. This supports the idea of Bilgin, Senocak, and Sozbilir (2009) that traditional lecture methods may not be sufficient to effectively teach the relevant concepts in science. They also added that to make learning more effective, teachers should act as facilitators rather than being “content experts” who provides facts and knowledge. They should encourage their students to become more involved in, and responsible for, their own learning. Though in the K to 12, curriculum, science is taught in spiral progression, the competencies are still broad and need to be unpacked which requires a lot of time to cover the topics intended for specific quarter. As cited by Paring, Cereno and Decano (2019) teachers were confronted with the dilemma that whenever they re-teach the previous concepts in science, it causes delays on the current learning competencies for the quarter because students cannot recall anymore the previous lessons. Hence, they either teach the current learning competencies at a faster rate to cope with the delays or follow students’ pacing yet unable to finish the entire lessons. As Lujan and DiCarlo (2006) stated in their paper, “the packed curriculum leaves little time for students to acquire deep understanding of the subject or to develop life-long skills such as critical thinking, problem solving and communication”. In effect, it provides less opportunity to address misconceptions properly. Furthermore, since students were not actively engaged in meaningful acquisition of concepts, they tend to easily forget the textual definitions of concepts thus making it hard for them to recall during examinations. This could possibly explain why a few students obtain a low score on the weekly assessment.

On the other hand, Appendix P shows the level of mastery of the students (respondents) in Life Science Achievement Test (LSAT) at the end of eight (8) -week of exposure to garden-based learning. Foregoing result reveals that 36 students were described as having Moving Towards Mastery (MTM) level, twenty-two (22) students performed Average Mastery (AM), eleven (11) students were categorized as in the

Closely Approximating Mastery (CAM) and one student were within the Low Mastery (LM) level.

It can be noted that the mean percentage score was 70.93 described as Moving Towards Mastery (MTM). This is relatively higher than the mean percentage score of the weekly assessment which is 59.34%. Notably, the number of students at the Closely Approximating Mastery (CAM) increased by 27 %, while 53% of those at Moving Towards Mastery (MTM). On the contrary, a decrease by 48 % and 50% were noted in the Average Mastery (AM) and Low Mastery (LM) levels respectively. The result indicated that garden-based learning was successful in improving the academic performance of students in life science subject. Gatdula and Gayeta (2019) observed similar findings, stating that students exposed to a garden-based strategy (GBS) influences their performance from average to high level in all topics covered in the life science subject.

Table 4.7. Students' Level of Performance on the Life Science Achievement

RANGE	FREQUENCY	PERCENTAGE	DESCRIPTIVE EQUIVALENT
96-100	0	0	Mastered (M)
86-95	11	15.71	Closely Approximating Mastery (CAM)
66-85	36	51.43	Moving Towards Mastery (MTM)
35-65	22	31.43	Average Mastery (AM)
16-34	1	1.43	Low Mastery (LM)
5-15	0	0	Very Low Mastery (VLM)
0-4	0	0	Absolutely No Mastery (ANM)
TOTAL	**70**	**100**	
OVERALL MEAN		**70.93**	**MOVING TOWARDS MASTERY**

The result concurs with the extant studies and anecdotal evidence that suggest that school gardens have the potential to enhance the academic curricula of both elementary and secondary schools, particularly in terms of science concepts (Klemmer, Waliczek & Zajicek, 2005). This could probably be because gardens, as a milieu for academic learning, provides opportunities to students to acquire meaningful and authentic learning experiences via hands-on activities as Williams and Dixon (2013) also claimed. Students were able see and experience firsthand what they are learning in the garden and apply what they had learned to real-life context. According to (Bento & Dias, 2017), hands-on learning has been shown to be essential in engaging learners in experiential learning and encouraging higher-level learning in the garden-based learning process. It creates dynamic environments for students to observe, investigate, study, and learn in. Through real-life experiences, students become active participants in learning which may help them enhance their acquisition of scientific knowledge, skills, and attitudes (Balaji,2017; Erdogan, 2017; Waliczek & Zajicek, 1999). This backs up Nittle's (2015) claim, which was highlighted by Ogden (2013), that studying in a natural environment aids student by engaging them on both a cognitive and sensory level. In this manner, everything comes alive in the garden, where abstract scientific concepts become more concrete, allowing students to remember them for longer than they would if they were taught by rote memorization. During exams, students could easily retrieve the principles they acquired in the garden.

The high cognitive and behavioral engagement of the student-participants towards GBL also accounts for the possible perceived improvements in their achievement scores in the life science achievement test. This can be shown in their positive responses to the questionnaire on level of engagement towards GBL as well as in their interview. Most of the students pointed out that garden-based approach allowed them to develop deeper understanding of the life science concepts and appreciate its practical application in real-life situations. Students also claimed that GBL enhanced their level of interest, motivation, and engagement in learning the subject, which shows perceived improvements their academic achievement, corroborating with the claim of Skinner et al. (2017).

Another plausible reason for the perceived improvements in the achievement scores of the students is that GBL fosters collaboration among students. Robinson and Zajicek (2005) asserted that “gardens provide a place where students can work together, make decisions, manage problems and gain a sense of responsibility”. Students work collaboratively to complete garden-based tasks and produce an excellent output. Throughout the process, they discuss the results and findings, as well as explain, evaluate, and defend their responses to conceptual issues posed by others from other viewpoints. According to Boyle and Nicol (2003), peer discussion allows opportunity to think about the topic in detail, examine various views and problem-solving techniques, and reconcile conflicting interpretations. Consequently, it will elaborate and build up students’ own framework of understanding. Antimivore (2011) articulated that student-centered small-group collaborative learning is more successful in increasing students' conceptual comprehension than typical lecture settings. Similarly, as Sahin (2007) pointed out in his study, group conversations are critical for absorbing basic ideas, since students actively participate in the things they are learning and form their own understanding of them.

The perceived improvements however in the students’ answers mirror the positive influence of GBL virtual classes in the students’ conceptual learning. Because they work in groups, they can discuss the concepts encountered among themselves. Once they present their ideas to their groupmates, these are further elaborated through the large group discussions and teacher’s feedback during virtual classes.

Furthermore, the teachers’ immediate feedback during online lecture sessions greatly influenced the students' conceptual understanding. Students received immediate feedback regarding their performance on weekly assessment every week. During these lecture sessions, students were able to realize what items they failed to answer correctly and able to know the correct answers to those item questions on the assessment test that they incorrectly answered. Misconceptions were also clarified and straightened out during online lecture sessions thus, increasing their conceptual understanding. This might also explain why students' LSAT scores have shown perceived improvements.

Overall, the Garden-based learning (GBL) strategy had a beneficial effect on students' level of performance in all life science subjects, as indicated in Table 4.8. The data show that the approach attains higher mean scores, as evidenced by the increasing gain in students' mean scores from lesson 1 (characteristics of living things) to lesson 5 (interaction and interdependence), most likely because students learned to adapt to the process and became familiar with the GBL approach to teaching life science.

Table 4.8. Comparison of Weekly Assessment and Life Science Achievement Test Mean Scores Across Different Lessons in Life Science

Topic	Mean Score		Mean Gain
	Weekly Assessment	LSAT	
I. Characteristics of Living Things	6.17	7.80	1.63
II. Photosynthesis	13.99	16.29	2.30
III. Plant Reproduction	8.66	11.13	2.47
IV. Plant Form and Function	14.87	17.37	2.50
V. Interaction and Interdependence	15.66	18.31	2.66

Although the LSAT mean scores of students were 11.59 higher than the weekly assessment, it was not enough to establish that the difference since no statistical analysis was used to evaluate the level of significant difference. Furthermore, the findings revealed that the mean percentage score of LSAT improved to 70.93 described as Moving Towards Mastery (MTM), still, it was not able to meet the 75% MPS target for national standards. This implies that students still need to improve their conceptual and procedural knowledge in science to master the learning competencies set by the department. In effect, this will expectedly produce good results in students' learning performance. This result conforms with the findings of Bernardo et al. (2008), Imam et al. (2014) and the reports of Benito (2014) and Briones (2014) regarding the low performance of Filipino learners in the NCAE and NAT in the area of science respectively.

However, in this study, it was found out that this pedagogical method of learning offers a lot of benefits to students namely, perceived improvements in their self-esteem and motivation, academic achievements, sense of responsibility, and the like. It also promoted students' attitudes and behavior morally and ethically. Consequently, the integration of garden-based learning resulted in a desirable academic performances and achievements of the students based on their test results. In addition, garden-based learning helps the students unlock the gap in their performances and by giving them an opportunity to be involved in the learning-teaching process through experiential approach, they achieved the ultimate goal of improving their skills (cognitive, behavioral, social, moral, and even spiritual) as well as their character on how to behave, perform, and act in the school correspondingly. The comparative mean scores in weekly assessment and LSAT showed that the performance of the students has perceived improvements and achieved a passing mark on the evaluation and upon the completion of their home gardening activities. All of them have positively affirmed that garden-based learning helped them in coping up the difficulty of Biology lessons. Based on the video made by the students, garden-based activities aided their learning in Biology and made it easier for them to understand. Through learning by doing, students were enabled to conquer their fear of Biology, better understand the concepts, and well-performed the application through outdoor activities or the home gardening. In this way, it somehow guaranteed that students could pass national level examinations.

Additionally, based on the item analysis done across life science achievement test scores disaggregated by topic, another noteworthy trend was seen in the data as reflected in Appendix P. In terms of the topics covered in the test, only one (1) question related to plant form and function emerged at the mastered (M) level by the students. Out of 70 respondents, 68 (97.14%) answered question no.64 correctly, *"Which of the illustration below shows a fibrous root system?"* (see Appendix I). During the conduct of the garden-based activity on From Seeds to Seedlings and Is it a Monocot or Dicot, students were able to observe and examine the difference between the two types of root systems exhibited by plants using actual specimens. This might be one of the reasons they could accurately answer the fibrous root system question. This assertion was supported by the students' interview responses. Below are some of the verbatim answers of the students during interview:

> *"The use of actual specimens like roots, stems and leaves of the plants helps me to better understand the structure instead of just merely looking at the picture or illustrations in our ADM module"* [Student 19, Female, 17]

> *"Because of the different hands-on activities, we had in this subject, I gained a thorough grasp of floral variations, the distinction between monocots and dicots, plant morphology, and many other topics."* [Student 5, Male, 17]

> *"Because of the epidemic, I never imagined studying Biology would be this so much fun. We were able to learn all the biology concepts even in the comfort of our home by using the various plants in our home garden as our learning material"* [Student 28, Female, 17]

The table also showed that from the 100-item test, 14 items were found at the Closely Approaching Mastery (CAM) level. From these items, questions related to interaction and interdependence obtained the highest frequency count of 8, and questions 10 and 19 gained the highest mean percentage score (see Appendix I).

> **Item No. 10** *"Cassie visits their home garden for her ecology project. Her teacher asked her to list down the abiotic factors in the ecosystem. Which of the following should NOT be included in her list?"* (f= 66; 94.29%)

> **Item No. 19** "*After cultivating a piece of land in your front yard, you transplanted the pechay seedlings in a way that they are equally spaced from one another as shown in the picture below. Identify the type of dispersion pattern is being exhibited by the lay out of your garden plot."* (f= 63; 90.00)

It is also interesting to note that item analysis of questions in the achievement test revealed that majority of the items were in the Average Mastery (AM) level. Fourteen (14) questions related to the topic of photosynthesis were found at this level. This concurs with Delos Santos, Lim and Rogayan Jr (2021) findings wherein photosynthesis is one of the least mastered competencies in Grade 9 science. Likewise, Sodervik, Virtanen and Mikkila- Erdmann (2014) cited that extant literatures present common misconceptions and difficulties encountered by high school and university students in understanding certain abstract photosynthesis concepts. Below are the accounts made by the students during the interview confirming that they had difficulty learning the lesson, thus score low in that part of the test:

> *"Limitado lang po ang aming natutuhan tungkol sa photosynthesis nuong kami ay nasa junior high school kasi gahol na po sa oras at kailangan na magproceed sa susunod na topic sabi ni Ma'am"* ("When we were in junior high school, we only leaned a little about photosynthesis and our teacher had to proceed to the next topic due to time constraint") [Student 6, Female, 17]
>
> *"Hopefully there will be more activities or experiments related to photosynthesis so that we can better understand the topic"* [Student 42, Male, 18]
>
> *"There is limited discussion on photosynthesis in our ADM module the reason why we had difficulty answering some of the questions in the exam, particularly those that deal with chemical processes involved in photosynthesis."*
> *"It is hard for us to understand the topic since we cannot see the actual process unlike in the previous topics, there are available hands-on experiment that will enable us to observe and investigate" [Student 51, Female, 17]*

In addition, it is also worth mentioning that question number 48 "Organisms produced by genetic engineering are different from organisms produced by sexual reproduction because ___" and question number 13 "Why do leaves of kangkong Ipomea aquatica, appear green?" obtained the lowest mean percentage score of 35.71% and 44.29% respectively (see Appendix I).

The result indicates that students demonstrated only fundamental knowledge and skills when it comes to the topic of genetic engineering and photosynthesis. Since most of the respondents are not on the Science, Technology, Engineering and Mathematics (STEM) track, they do not see the relevance of studying the concept in their future career since they are taking Humanities and Social Sciences (HUMSS), Accountancy, Business and Management (ABM), Automotive Servicing (AS), Computer Systems Servicing (CSS) and Electrical Installation and Maintenance (EIM). As mentioned above, the lack of hands-on experiments due to unavailability of materials and equipment at home, limited discussion in the module and limited time for online discussion were the possible reasons for the low MPS of the two items.

Attitude Towards Biology

In this study, several variables were measured and analyzed to determine students' attitudes toward biology. They include the importance of biology, interest in Biology lessons, perceptions of the Biology teachers, keenness to learn Biology, enjoyment of Biology, anxiety towards Biology, and effort in learning Biology. The results of the study for each of these variables are discussed in detail below:

Importance of Biology

Table 4.9 shows the result of the survey of students' attitudes towards Biology in terms of the importance of Biology in their personal lives. As indicated in the table below, students' overall attitude towards the importance of Biology is positive with an overall mean of 3.36 although the individual statements received a positive to very positive students' attitude.

Table 4.9. Students' Attitude Towards the Importance of Biology (n=70)

Items	Mean	Descriptive Rating	Descriptive Interpretation
Biology is an important part of our lives.	3.60	Strongly Agree	Very Positive
We learn important things in biology class.	3.47	Agree	Positive
The progress of biology improves the quality of our lives.	3.41	Agree	Positive
Biology helps me in the development of my conceptual skills	3.39	Agree	Positive
Biology is our hope for solving many environmental issues and problems.	3.36	Agree	Positive
The work with living organisms in biology lessons are very interesting.	3.34	Agree	Positive
Knowledge in biology is essential for understanding other courses and phenomena.	3.30	Agree	Positive
Everybody needs knowledge of biology.	3.29	Agree	Positive
I find the biological process very interesting.	3.24	Agree	Positive
I make many efforts to understand biology.	3.21	Agree	Positive
Overall Mean	**3.36**	**Agree**	**Positive**

Legend: 3.50- 4.00 (Very Positive), 2.50-3.49 (Positive), 1.50-2.49 (Negative), 1.00- 1.49 (Very Negative)

Remarkably, students positively viewed "*Biology is essential part of our lives"* (mean = 3.60) since whatever "*progress or advancement in Biology would be gearing towards perceived improvements of the quality of human lives*" (mean = 3.41) and in finding solutions that would "*solve many issues and problems in our environment"* (mean = 3.36). Results suggests that the students may have an inherent appreciation of the importance of biology because many of the problems and challenges confronting the world recently (e.g. COVID-19 pandemic, ethical issues and efficacy of COVID-19 vaccines, viral mutation, endangered species, and climate change) are biology-related. Their exposure through several social media platforms to such problems and the advances in science that address them may have affected their perception on the importance of the field. It is also interesting to note that respondents agreed that "*they learn important things in biology class*" (mean = 3.47), "*they find studying biological processes very interesting*" (mean = 3.24) and "*Biology helps them in developing their conceptual skills*" (mean = 3.39).

Their agreement with these statements could be due to their first-hand observation of the relationship between the garden and their daily life. With the various activities using the garden, students were able to realize how important studying biology to their lives. For instance, one student expressed this thought "…*nung nangongolekta ako ng mga iba't ibang uri ng dahon para sa HERBARIUM naming grupo sa pamamagitan ng pagtukoy ng mga magagandang hatid nito sa kalusugan natin…*" when asked on which part of the activity they liked the most. Learning the various health benefits of the plants that they collected, the student could have related the study of biology to discovering the plants that could improve personal health wellness aside from developing some conceptual skills. Such a relationship may have increased the student's interest in Biology, hence the positive attitude towards the importance of Biology. Even though studying Biology is difficult, yet, through the integration of garden-based learning, such a difficulty has been properly addressed and conquered by letting the students explore, acquire learning, and share this learning with others (Subramaniam, 2002) and discover essential things (not only in the field of Biology but also to other life sciences) by experiential learning approach (Klemmer et al., 2005). This supports the argument that generally students tend to develop positive attitude towards science in the context of the society (Ebenezer & Zoller, 1993; Sundberg, Dini & Li, 1994; Breakwell & Beardsell, 1992).

They also expressed that the advancement in biology leads to the improvements of the quality of our lives. Millions of lives were saved worldwide due to the rapid identification of a vaccine against Covid-19. Students' exposure to various social media platforms that feature national and local issues like emergence of different variants of Covid-19, discovery of new species of plants and animals, advancement in the field of biotechnology, medicine and nanotechnology could also affect their perception of the subject. In addition, it is also interesting to note that respondents agreed that the things that they learned from the subject increased their science conceptual knowledge and process skills. This could be an evidence that the goal of science education has been achieved (Ong & Yeo, 2012).

Generally, through the post-interview with the students, they understood how important planting is in people's daily activities. The pandemic opens an opportunity to enhance skills in planting and how this could help sustain biodiversity. The hands-on activities give them additional ideas concerning the applications of Biology lessons.

> *"I realized that not all plants are cultivated in soil; others are grown in hydroponics systems, and this technology might be a viable answer to our country's food shortages."* [Student No. 4, Female, 16]

> *"The use of biological principles and theories aided scientists all around the world in developing vaccines to combat the Covid-19 virus. Our topic also taught us how to protect oneself and our loved ones from contracting the infection."* [Student No. 9, Female,17]

> ***"**Sa pamamagitan po ng mga garden-based activities, mas naintindihan po namin ang kahalagahan ng biology at ang kaugnayan nito sa aming pang-araw -araw na pamumuhay" [*We gained a greater understanding of the importance of biology and its relevance to our daily lives through garden-based activities*]* [Student No. 12, Male,17]

Interest in Biology Lesson

Using negative statements, the study explored the respondents' interest in Biology. The results indicate that they have developed interest in Biology lessons. Table 4.10 indicates that they disagree to strongly disagree with the negative statements about Biology lessons with an overall mean of 3.45.

Table 4.10. Students' Interest in Biology Lesson (n=70)

Items	Mean	Descriptive Rating	Descriptive Interpretation
I do not have the interest to discuss biology topics after school time. *	3.66	Strongly Disagree	Very Negative
The lessons taught in biology are not interesting. *	3.57	Strongly Disagree	Very Negative
I would not probably do well in a course related to biology. *	3.56	Strongly Disagree	Very Negative
I do not have an interest to complete my homework in biology. *	3.51	Strongly Disagree	Very Negative
I cannot understand the biology lessons after class. *	3.47	Disagree	Negative
Biology lessons become a source of boredom for me. *	3.46	Disagree	Negative
I hate biology lessons. *	3.43	Disagree	Negative
My mind goes blank when I am studying biology. *	2.94	Disagree	Negative
Overall Mean	**3.45**	**Disagree**	**Negative**

*Legend: * reverse-scored; 3.50- 4.00 (Very Negative), 2.50-3.49 (Negative), 1.50-2.49 (Positive), 1.00- 1.49 (Very Positive)*

Their response shows that the garden-based approach to teaching Biology has developed their interest in the lessons. In fact, they strongly disagreed with the statement that they have no interest in discussing the lessons even outside of their school time. This statement received the highest weighted mean (3.66), indicating that the students are still interested in discussing their lessons even outside their class hours. This is also indicated with their negative responses to the statements "*The lessons taught in biology are not interesting*" (mean = 3.57) and "*Biology lessons become a source of boredom for me,*" (mean= 3.46). Any students who have developed interests in their lessons will tend to have an increased attention and engagement in the course as Harackiewicz et al. (2018) had indicated. This interest could be the powerful motivational process that guided and energized the students to learn their lessons and complete their requirements (Harackiewicz et al., 2018). This is also indicated in their strong disagreement to the statement "*I do not have an interest to complete my homework in biology*" with a mean of 3.51, which indicates that they are interested to complete their homework.

Likewise, the results also indicate that the students clearly understood their lessons such that they still remember them even after their class (mean = 3.47) and they think they can perform well in any Biology related courses (mean = 3.56). These results could show that the purpose of garden-based strategy in developing interest in learning among the students had been achieved. Eugenio-Gozalbo et al. (2020) reported that such students' responses could be due to the ability of gardens to facilitate the establishment of connections between new learning and personal interests and students' prior knowledge. They observed that such interest stemmed from the students' learning of plants' anatomical traits and diversity. Tello and Diaz (2017) in Eugenio-Gozalbo et al. (2020) also indicated that such interest could have developed when gardens are able to connect "abstract learning with individual and collective experiential learnings and integrate activities of daily life with curricular content" [Introduction]. Subramaniam (2002) also pointed out that when learning is concrete and shared, information absorption is high. Garden-based learning makes abstract theories concrete and learning shared. Subramaniam (2002) also pointed out that information absorption is high when learning is concrete and shared. This may explain students' disagreement to the statement "*I cannot understand the biology lessons after class*."

Perception Towards the Biology Teacher

Students' perception of their biology teacher is characterized by their perception on teacher's preparation, teaching, student support, interaction with the students, and interpersonal relationship. Table 4.11 summarizes the results of the students' perception of their teacher.

Table 4.11. Students' Perceptions of the Biology Teacher (N=70)

Items	Mean	Descriptive Rating	Descriptive Interpretation
My biology teacher makes a good plan for us.	3.50	Strongly Agree	Very Positive
Whenever I want to ask anything about biology, I consult my biology teacher.	3.50	Strongly Agree	Very Positive
The important points emphasized by my teacher during class discussion help me in learning biology.	3.44	Agree	Positive
We do a lot of fun activities in biology class.	3.40	Agree	Positive
My biology teacher encourages me to learn more about biology.	3.30	Agree	Positive
I understand biology lessons taught in class by the teacher.	3.23	Agree	Positive
I enjoy talking to my biology teacher after class.	3.09	Agree	Positive
I consult my biology teacher on any topic/s that I cannot understand during science class.	3.01	Agree	Positive
Overall Mean	**3.31**	**Agree**	**Positive**

Legend: 3.50- 4.00 (Very Positive), 2.50-3.49 (Positive), 1.50-2.49 (Negative), 1.00- 1.49 (Very Negative)

As can be gleaned in the table, the overall mean of the students' perception is 3.31 indicating their positive perception towards their Biology teacher. Specifically, the students had a very positive perception towards their teacher's preparation or plan for them as well as student support in a form of the teacher's availability for consultation. This is critical because students' perception of their teacher is important in developing a positive attitude towards Biology (Fetalvero, 2016). In addition, having a positive perception of the support provided by their teacher may widen the communication channel between them and their teacher, consequently resulting in more productive academic interactions between them. In fact, students could openly ask anything about the experiential and outdoor activities from the teacher throughout the study.

This also explains why students agreed to the statement "*I enjoy talking to my biology teacher after class*" (mean = 3.09). Ozacan (2003) and Tatar and Oktav (2007) had emphasized that such an attitude towards the teacher indicates students' satisfaction in the teaching-learning process, enjoyment in class management, and pleasure with the company of their teacher. In contrast, if students are unhappy with how biology lessons are delivered, it may lead to a negative attitude towards their teacher, and consequently, unhealthy interactions may occur. Elliot (2015) had indicated that an effective implementation of the garden-based learning will promote good teacher-student relationships where students feel a sense of belongingness and experience an enhanced ability to interact especially with their teachers. In the study, this can explain the students' agreement to the statements "*My biology teacher encourages me to learn more about biology*," and "*I consult my biology teacher on any topic/s that I cannot understand during science class*." In both cases, it appears that the teacher has become a good source of encouragement as well as knowledge for the students (YouthLearn Initiative, 2021). The teacher has become a guide to the students on what they were supposed to learn and master at the school. One student commented, "*He gives us clear instructions before we proceed to the conduct of our activity. He also provides us the materials that we need in our activity* [Student 37]."

Their interactions using the garden-based learning may have contributed to their understanding of the concepts discussed in the class, as one student indicated, "*He was able to explain biological concepts in the context of home garden thus we understand it easily* [Student 48]." The various garden-based learning activities may have provided the venue for the better interactions between the teacher and the students and increased collaborations among the students and with their community and families (Swank and Swank, 2013). Such collaborations may have enhanced their ability to understand the abstract concepts of Biology.

Although Biology has been perceived to be a relatively difficult subject, the students gained a better appreciation of it as indicated in the above discussion possibly because of the better interactions with their teacher (Fetalvero, 2016). Hence, it can be inferred that teachers' teaching styles can affect students' comprehension and attitude towards the subject matter they taught (Cimer, 2004). How teachers presented the content to the students, facilitated the discussion, and managed feedback on students' performance may strongly influence their relationship with their students (Vedder, 2018). This has been implied in the following students' interview responses:

> "*I'm really impressed with our teacher's teaching style and how he makes our biology class so much exciting and enjoyable. Although we meet virtually/online, he does not fail to make the discussion lively and engaging.*" [Student 48, Female, 16]

> "*He offers us timely feedback on our performance in class and in our activities on a regular basis. He is also approachable and immediately attend our concerns through chat or text.*" [Student 43, Male,16]

The integration of garden-based learning approach has provided the students with the space to explore new things that concretize the abstract concepts of Biology, hence, their appreciation of the subject matter as well as to their teacher for giving them such an opportunity. Several authors (e.g., Lazarowitz & Penso, 1992; Tekkaya et. al., 2001; Cimer, 2004; Zeidan, 2010) had reported that Biology had been perceived as a difficult subject because of its abstract nature, which is coupled with the teacher-centered teaching styles that limits students' opportunity to explore new things outside the classroom. However, the integration of the garden-based approach in the delivery of the subject's content may have captured the students' interest and motivated them to learn effectively and perform better.

Keenness to Learn Biology

Table 4.12 summarizes the students' attitudes towards Biology in terms of their keenness to learn Biology. Based on the overall mean of their responses (om = 3.19), the students are found to be keen to learn Biology. Specifically, they do not only follow a regular time schedule to study Biology at home, but they also review daily their lessons at home. During class hours, they are keen to focus on the discussion. Consequently, they understand the important points being discussed, and even explain these concepts in their own words.

As Skinner et al. (2012) had pointed out, the training of the students to put attention and focus on the details on their garden-based learning activities may have facilitated the development of such behavioral engagement of the students. They reported that students usually focused on the details in their activities and considered studying them at home. With these being done routinely at home, the students could have developed such a behavior, which had persisted during their class sessions. This could explain why students are highly motivated to focus on their Biology lessons during class hours (Cortero, 2019).

Table 4.12. Students' Keenness to Learn Biology (N=70)

Items	Mean	Descriptive Rating	Descriptive Interpretation
I follow a regular schedule to study biology at home.	3.44	Agree	Positive
I can focus on biology lessons.	3.36	Agree	Positive
I fully concentrate on the topic discussed in my biology class.	3.33	Agree	Positive
I usually relate the previously learned lessons in biology with the new one.	3.19	Agree	Positive
During biology lectures, I can comprehend the important points.	3.16	Agree	Positive
I complete first my homework in biology before doing other things.	3.10	Agree	Positive
I review lessons in biology daily at home.	3.00	Agree	Positive
I can explain biology concepts in my own words.	2.93	Agree	Positive
Overall Mean	**3.19**	**Agree**	**Positive**

Legend: 3.50- 4.00 (Very Positive), 2.50-3.49 (Positive), 1.75-2.49 (Negative), 1.00- 1.74 (Very Negative)

Furthermore, students are keen to complete their Biology assignments first before doing other things. This indicates that students prioritize their learning of the subject matter more than their other responsibilities. Having such positive attitude towards learning Biology can help them perform better. According to Diez-Palomar et al (2020), attitude is an important factor influencing students' performance. Their keenness to review daily their lessons in Biology at home coupled with their positive attitude towards synchronous study sessions and completing their assignments are expected to help them achieve their learning goals.

It is possible that the garden-based learning activities have grabbed students' attention, which develops their interest to review and focus better. Bjorge et al (2017) had reported that outdoor learning such as the garden-based learning offers students a unique and rich context to frame their learning. They further indicated that such an approach could provide students with movement and stimulation that grab their attention so they can focus better. Cameron and McGue (2019) also indicated that incorporating regularly outdoor learning activities in a classroom can help students move and explore on a sensorial level that may promote positive learning abilities, one of which is prioritizing their learning.

In fact, they suggested that using outdoor learning activities such as those being done in gardens can positively impact students who are not successful in an indoor classroom setting. Bjorge et al. (2017) further implied that outdoor learning activities can greatly improve students' motivation, concentration behaviors, and overall well-being, which when properly tapped can translate into better performance. In the study, it is expected that the exploratory as well as the experimental approach of the garden-based learning activities had encouraged students to review their lessons, explore possibilities, and discover new things. In turn, by having hands-on experiences in discovering new things through their garden-based learning activities, the students may have developed their critical thinking as well as independent learning skills as Haury and Rillero (1994) indicated. Boss (2001) has also indicated that the inquiry-based learning aspect of the garden-based learning allows students to construct knowledge independently. Allowing them to explore and discover new things in the garden helped them see the concretization of the abstract concepts in Biology and thus, understand more about these concepts as expressed in the following interview responses of the students:

"I got a deep understanding of floral variations, evidence of photosynthesis, plant cells, morphology and many more that made me realize that science is really interesting to learn." [Student No. 27, Male, 17]

"The experiments we had helped me to properly analyze the lesson. It clearly shows result that makes me analyze different thoughts and conclude strong idea after performing experiments." [Student No. 13, Female, 17]

"Dati sobrang takot ako sa science kasi madami sauluhin tapos ang hihirap pa ng exam. Ngayon po eh hindi na kasi masaya po kami sa ginagawa po tapos mas madali namin matandaan ang mga pinagaralan."[I used to be scared of science because there was so much to remember and the exams were so difficult. Now it's not because we're happy with what we're doing, which makes recalling what we've learned less difficult.] [Student No. 35, Male, 16]

"Yes, after this garden-based activity, I have appreciated biology even more. I like the way how my eyes and mind became wider as we tackle biology." [Student No. 51, Female, 17]

Consequently, students are able to explain biological concepts in their own words according to what they have observed in the gardens and connect their prior knowledge to the new lessons taught to them. This could explain their agreements on the statements "*I can explain biology concepts in my own words*" and "*I usually relate the previously learned lessons in biology with the new one.*" This is also evident in the following interview response of a student:

"The garden-based activity helps me in understanding the topics discussed in my ADM Modules, as we experienced it hands on. With this garden-based activity, we have encounter different ups and downs which made us to learn furthermore." [Student 7, Female, 16]

Enjoyment of Biology

Overall, students agreed that they enjoy learning biology. The overall mean is 3.11, indicating an enjoyable attitude towards learning biology (Table 4.13). As Skinner et al. (2012) had reported, the integration of garden-based learning can provide excitement, enjoyment, and interest to students in learning biology. In addition, Haury and Rillero (1994) had indicated that the hands-on methods of learning and outdoor activities in garden-based learning can motivate and develop students' positivity, enjoyment of learning, and creativity (Haury & Rillero, 1994). In the study, these are indicated with the students' agreement on the following statements:

"I enjoy learning biology."

"I feel a definite positive reaction to biology because it is enjoyable."

"Biology is a very interesting subject."

The use of garden-based learning approach in the study could have made the learning process more immediate and familiar to the students. DiClaudio et al. (2013) emphasized that "Learning is most effective when the subject matter is "demystified," that is, when it is immediate and familiar to the learner" [par. 3]. For instance, the various garden-based activities may have allowed the students to investigate and compare the basic physical characteristics of plants, the factors that helps or hinders their growth, the diversity of plants and plant structures, and plant responses to any environmental stimuli. These activities have provided them with the immediate information under a familiar concrete environment as compared to the highly theoretical and abstract lecture of teachers inside a classroom.

Table 4.13. Students' Enjoyment to Learn Biology (N=70)

Items	Mean	Descriptive Rating	Descriptive Interpretation
I enjoy learning biology.	3.30	Agree	Positive
I feel a definite positive reaction to biology because it is enjoyable.	3.27	Agree	Positive
Biology is fascinating and fun.	3.26	Agree	Positive
Biology is not boring.	3.24	Agree	Positive
Biology is a very interesting subject.	3.09	Agree	Positive
I would enjoy being a biologist.	3.09	Agree	Positive
I really like biology.	3.04	Agree	Positive
I am looking forward to our biology class.	2.56	Agree	Positive
Overall Mean	**3.11**	**Agree**	**Positive**

Legend: 3.50- 4.00 (Very Positive), 2.50-3.49 (Positive), 1.50-2.49 (Negative), 1.00- 1.49 (Very Negative)

Consequently, this has allowed students to connect the content of their learning materials with reality. Having seen such a connection, students' positive attitude towards learning their lessons may have been increased, hence, their agreement to the statement, "*I am looking forward to our biology class*." DiClaudio et al. (2013) reported such a relationship. They observed that students' positive attitudes towards content material and learning increased when they were allowed to engage in hands-on gardening.

This is critical for science education [in general] because as Ong and Yeo (2012) had emphasized, developing students' positive attitudes towards science should be an essential goal of science education. Developing a positive attitude towards science in general or biology in particular may help students attain various academic and non-academic outcomes (Williams & Dixon, 2013) including good academic performance (DiClaudio et al., 2013); better interpersonal relationships with their classmates and teachers (Elliott, 2015); and positive attitude towards the environment (Fisher-Maltese & Zimmerman, 2015). Garden-based activities provide the opportunity for students and teachers to work together.

In addition, the garden-based learning developed the fascination towards biology among the students. These are indicated in their agreements on the following statements: "*Biology is fascinating and fun*" and "*I would enjoy being a biologist*." The computed mean for these statements is 3.26 and 3.09, which indicate a positive attitude towards learning biology. Such fascinations were expressed in the following responses of students during the interview:

> *"I feel amazed, hopeful, thankful and interested. Amazed because there are some activities that make me "wowed" specifically when we are investigating plant cells using the microscope. Hopeful because we experience many trials before we reach success in the activity. Thankful because we were able to accomplish our activities on time. Interested because it opens my mind to search and investigate things I am interested at."* [Student No. 11, Female, 17]

> *"In this GB activities, I would like to describe my experience as enjoyable, gratifying and memorable. And one thing is for sure, it will help me in the future."* [Student No. 46, Female, 17]

> *"When we are filming our activity that was the part that I like the most because we are enjoying the activity that we do."* [Student No. 10, Female, 16]

The students' engagement in various garden-based activities may have increased their liking towards biology. As indicated in Student No. 11's response, connections to content learned in the classroom were strengthened through their involvement in the garden-based activities. The activities had provided them the opportunity to explore and discover biological contents on their own. Other studies such as those conducted by Eugenio-Gozalbo et al. (2019) and Tello and Diaz (2017) as cited in Eugenio-Gozalbo et al. (2020) had indicated that students' engagement in garden-based activities can arouse their interest and motivation toward learning and help connect abstract learning with individual and collective experiential learnings. Furthermore, Tello and Diaz (2017) had pointed out that gardens help integrate activities of daily life with curricular content. Such an integration can trigger students' enjoyment in learning as Eugenio-Gozalbo et al. (2020) had suggested and as Student No. 10 had expressed during the interview.

Anxiety Towards Biology

The above observations have also been confirmed by the results of the assessment of students' anxiety towards biology. The statements were presented as negated or negative expressions; thus, the weighted means for these statements will indicate disagreements or negative attitudes. As indicated in Table 4.14, the overall mean is 3.25 indicating students' general disagreement with the statements, which can mean having less or no anxiety towards biology. These results have just confirmed the enjoyment of students in learning biology through the garden-based learning approach. Specifically, students have no dislike towards biology, not uncomfortable with it, not scared about it, have no feeling of hesitation to learn about it, and have no terrible strain in a biology class. In fact, they always look forward to their biology classes and described their experiences as always feeling comfortable, relaxed, calm, and instilling patience in them. In an instant they are scared in attending any study session in biology or felt the strain rather they developed a high likeness of the subject. This is critical because Ozacan (2003) and Tatar and Oktav (2007) reported that students' feelings of dislike may later turn into being disinterested. Fetalvero (2016) also observed that disinterest is among the students' attitudes towards biology he observed. Some negative attitudes towards science have been observed to cause low student performance and achievement in science-related tests (Fetalvero, 2017; UNESCO, 2010).

Table 4.14. Students' Anxiety Towards Biology (N=70)

Items	Mean	Descriptive Rating	Descriptive Interpretation
When I hear the word "biology", I have a feeling of dislike. *	3.46	Disagree	Negative
Biology makes me feel uncomfortable, restless, irritable and impatient. *	3.41	Disagree	Negative
For me, biology seems scary. *	3.37	Disagree	Negative
I approach biology with a feeling of hesitation. *	3.13	Disagree	Negative
I am always in terrible strain in a biology class. *	2.90	Disagree	Negative
Overall Mean	**3.25**	**Disagree**	**Negative**

*Legend: * reverse-scored; 3.50- 4.00 (Very Negative), 2.50-3.49 (Negative), 1.50-2.49 (Positive), 1.00- 1.49 (Very Positive)*

These results could indicate that important role of the garden-based learning approach in eradicating students' anxiety towards biology. As Guerrero (2016) indicated, the approach can ignite students' interest in learning and their performance. This could be explained by the capacity of the approach to facilitate the promotion of a meaningful biology learning through the establishment of connections between previous knowledge, personal interests, and new learning (Eugenio-Gozalbo et al., 2020). As Student No. 11 had expressed "*Interested because it opens my mind to search and investigate things I am interested at,"* it is apparent that the approach was able to stir students' interest because they were given the opportunity to "*search and investigate*" the things they are interested in. Although the natural tendency of students when it comes to Biology learning is to become scary and anxious, the students' disagreement with the statements indicates that the approach reduced their anxiety. The capacity of the approach to include the students in the teaching-learning process may have 'unlocked' their anxiety and replaced it with enjoyment. According to Palmberg and Kuru (2000), if students are included in the teaching-learning process, they would be able to resolve or unlock their anxiety, which in turn, leads them to learn new things.

The negative responses given by the students to all the statements show that incorporating garden-based activities in their biology lessons helped them reduce anxiety towards the subject. As Sullivan (year) had suggested, a garden-based learning approach can make students calm and relaxed while engaging in their learning activities.

Effort in Learning Biology

In terms of the efforts exerted in learning biology, students' responses to the survey indicated a positive attitude, which means that they are more likely to put greater effort in learning the course. The overall mean for this variable is 3.39, which indicates their agreement with all the statements presented to them as reflected in Table 4.15. They strongly agreed (mean = 3.56) to the statement "*I always try to do my best in biology*," which shows that they are willing to exert more effort to perform their best in the course.

Williams et al. (2018) indicated that learning in the garden has allowed students to engage in authentic, real-world learning of science including biology that shapes their motivation in learning and develops an academic identity in science. They highlighted that garden-based learning had allowed students to view themselves as competent, related, and autonomous in the learning process. Their engagement and re-engagement in the garden can potentially pave the way for the development of their academic identity in science (Williams et al., 2018). Again, this emphasizes the role of teachers' teaching approaches in motivating students to learn as Cimer (2004) had indicated. Cimer (2004) had emphasized that the teaching-learning method matters in learning biological concepts because it affects students' performance and motivation. When the approach encourages students, they are motivated to do their best.

Table 4.15. Students' Effort in Learning Biology (N=70)

Items	Mean	Descriptive Rating	Descriptive Interpretation
I always try to do my best in biology.	3.56	Strongly Agree	Very Positive
I always try hard no matter how difficult the lesson in biology is.	3.40	Agree	Positive
I try hard to do well in biology.	3.34	Agree	Positive
When I fail in biology exam, I always try much harder.	3.27	Agree	Positive
Overall Mean	**3.39**	**Agree**	**Positive**

Legend: 1.00- 1.49- Very Negative,1.50-2.49- Negative, 2.50-3.49- Positive, 3.50- 4.00- Very Positive

In addition, the students are willing to try hard to learn especially their difficult lessons in biology. This statement received a mean of 3.40 (see Table 4.15) indicating their agreement with the statement. The result also shows that the students are hopeful to overcome their difficulties in the learning process. As Student No. 11 has indicated in the interview, "*Hopeful because we experience many trials before we reach success in the activity.*" Despite the difficulties they experienced, they still tried hard enough to be able to attain success in their learning activities. This is consistent with the theory of self-determination (Skinner et. al, 2008) where students persisted because they are determined to successfully engage in the learning process. The attitude of the student of not giving up indicates that they will exert exceptional effort to pass and give out their best performance in the course (Skinner et al., 2012). Williams et al. (2018) observed similar results in their study. They further suggested that such findings "can be useful in identifying some of the "active ingredients" - in pedagogy, curriculum, and social relationships - that engage students in these garden-integrated science learning activities" [p.1].

This attitude is further exhibited by the students' agreement with the statement "*When I fail in biology exam, I always try much harder*," which has a mean of 3.27. Being determined to succeed, the students are less likely to quit even if they fail once or twice in what they do in the course. According to Lopez-Garrido (2021), students become self-determined when their needs for competence, relatedness, and autonomy are being fulfilled. Williams et al. (2018) indicated that learning in the garden has fulfilled these students' needs. Skinner et al. (2012) pointed out that this could be translated into passing in achievement tests. Thus, Draper and Freedman (2010) considered this as one of the benefits of using garden-based learning, which helps students achieve their academic goals and gain more knowledge. This is achieved by developing the persistence, hard work, and enthusiasm that students need in learning biology (Skinner et. al., 2008). Encarta (2009) has also indicated that garden-based learning allows students to exert mental and physical energy to learn about biology despite their failures, challenges, and shortcomings. Such behavioral engagement explained the efforts exercised by the students in every academic activity (Skinner et al., 2012) as indicated in the following interview responses:

> *"One of the challenges I have encountered is the weather, throughout the journey, the weather aren't always good. Fortunately, we have figured it out and was still able to work on it well."* [Student No. 7, Female, 16]
>
> *"The part of the activity I enjoyed the most is seeing the results of our experiment and seeing that our efforts were worth it. Doing experimental activities were not easy for us but we made sure to do our best in performing our task efficiently and witnessing how our hardships paid off truly made me feel at ease."* [Student No. 3, Male, 17]
>
> *"Well, it is quite hard and challenging but I really enjoy it the mere fact that in gives satisfaction and it makes us more knowledgeable when it comes to biology. We did those activities right and we properly analyze it, so it may be hard but following the steps makes it easy."* [Student No. 13, Female, 17]

These responses showed how students overcame their hurdles in learning in the gardens. Despite of their challenges and difficulties, they were able to successfully engage in their learning activities by exerting more effort in understanding them (*Student No. 7*), doing the tasks efficiently (*Student No. 3*), and properly analyzing and carefully following the steps (*Student No. 13*). Again, such a students' behavior towards learning biology could be due to the capacity of the garden-based learning to increase their interests, persistence, curiosity, cooperation, open mindedness, and critical thinking (Priyayi et al., 2020). As indicated in the previous students' responses to the interview and Priyayi et al. (2020), students feel more energized in performing outdoor educational activities, encourage to work in teams and explore the phenomenon that is happening, and highly motivated to overcome learning barriers and/or challenges. This is critical because just as Hammarsten et al (2019) had pointed out, these outcomes can result in the development of students' practical competence i.e. learning how to co-exist and care and biological knowledge and ecological understanding, which may be beneficial for both the communities and the environment.

Association between the Extent of Engagement in Garden-Based Learning and the Profile Variables

Association between socio-demographic variables of the learners such as age and sex and dimensions of extent of engagement were computed. Cramer's V was computed to measure the association between age and each dimension of extent of engagement. Based on Table 4.16, there is a negative very weak monotonic association between age and both cognitive and emotional dimensions of extent of engagement. Moreover, a positive very weak monotonic association was observed between age and behavioral dimension of extent of engagement.

On the other hand, Cramer's V was computed to measure the association between age and each dimension of extent of engagement. As seen in Table 4.16, all dimensions of extent of engagement have a low association with sex.

Categorical data related to the socio-demographic variables of learners, specifically age and sex, were analyzed for their association with different dimensions of engagement. Non-probability sampling was employed to gather data, emphasizing the use of Cramer's V as a statistical treatment. Kendall's Tau correlation coefficient was calculated to assess the association between age and each dimension of engagement, revealing a negative and very weak monotonic association between age and cognitive and emotional dimensions, while a positive very weak monotonic association was observed between age and the behavioral dimension of engagement. Simultaneously, Cramer's V was applied to measure the association between age and each dimension of engagement, indicating a low association between all dimensions of engagement and sex, reinforcing the appropriateness of Cramer's V for the categorical data and non-probability sampling employed in this study.

Table 4.16. Measures of Association between Dimensions of Extent of Engagement in Garden-based Learning and Age & Sex Profile Variables

	Extent of Engagement		
	Cognitive	**Behavioral**	**Emotional**
Age	-0.0576	0.0165	-0.0086
Sex	0.1206	0.1365	0.0111

The study explored the relationship between age, sex, and various dimensions of student engagement in garden-based learning. The results, conveyed through Cramer's V values, reveal weak or very weak correlations. Specifically, concerning age, there is a very weak negative association with cognitive engagement (-0.0576) and emotional engagement (-0.0086), while a very weak positive association is observed with behavioral engagement (0.0165). Regarding sex, there are very weak positive associations with cognitive engagement (0.1206), behavioral engagement (0.1365), and emotional engagement (0.0111).

The absence of strong correlation in these results suggests that, in the context of this study, neither age nor sex influences the extent of student engagement in garden-based learning. This lack of correlation could be attributed to factors such as a narrow age range among participants or a balanced distribution across sexes, resulting in limited variability in these demographic variables. Essentially, the findings imply that the engagement levels observed in garden-based learning are relatively consistent across different age groups and sexes, making these demographic factors poor indicators of engagement extent in this educational context.

The results indicate that the age and sex of the students do not influence the extent of their engagement in a garden-based learning. This could be due to the low variability of these factors among the students. For instance, the lowest age of the participants is 16 years old while the highest is 18, indicating just a 2-year difference between the two. There is also a uniform distribution of students across sex. Expectedly, these variables may not be good determinants for the extent of engagement of students in this study although several research studies indicate similar results i.e. higher extent of participants' engagement in garden-based learning regardless of age and sex. For instance, reported that students with ages 9-15 years old are highly engaged in the learning process using school gardens. Such an extent of engagement had resulted in increased children's awareness about vegetables, their knowledge about sustainable agriculture, and their preferences for healthier foods" [p. 1]. Pierce and Ziegler (2008) also indicated a positive engagement among homeless women with age range of 22-43 in a garden-based learning program in the United States of America. They reported that their participation in the program had practically improved their level of hopefulness and self-efficacy. Williams (2018) further indicated that garden-based learning has elicited students' interest in both sexes from pre-school to high school and thus, educators used it for a variety of reasons.

The findings can justify the adoption of garden-based learning strategy across age groups and sex. Since the approach is not sensitive to any age group or sex, it can facilitate the enhancement of the biological knowledge and competencies of the students in all levels and sex. This is important to allow students employ new learning styles, develop better perspectives and ways of learning, and incorporate critical 21st-century skills such as curiosity, flexibility, open-mindedness, informed skepticism, creativity, and critical thinking especially in Biology in particular or Science in general as Stayer (2015) had indicated. These are indicated in the students' responses in the interview when asked whether the garden-based learning had helped them better understand the concepts presented to them through the ADM module, to wit:

> *"It helps me a lot specially to those activities that need deep understanding. Now that we are in the new normal learning system, it is very essential because it is hands-on, and it requires effort, dedication and focus so that the concepts are well understood." [Student No. 2]*
>
> *"The garden-based activities help me better understand the given topic….and through experimenting, observing, researching, and listening, I better understand these topics." [Student No. 1]*
>
> *"As a whole, garden-based activity really helped a lot; it emphasizes the idea about biology. Through performing different garden-based activities, it makes easy to fully understand and analyse the topic, the idea of having garden-based activity makes our mind more knowledgeable when it comes to biology." [Student No. 13]*

Mohamed and Alsayed (2021) strongly suggested that engagement of students in garden-based learning should be viewed as a critical component of the learning process that is reliant on the desire of students to study. As it enhances students' engagement at various age levels and sex, it should be looked at as a tangible solution to address disaffection of students in learning. This is necessary because as Williams (2018) indicated in his article "Garden-Based Education," disaffection and disengagement can result in a school dropout crisis. Being a teaching method that encourages active learning among the students, the adoption of garden-based learning strategy at all levels may result in better student learning outcomes. It is important to note that active learning suggests that the pupils are driven to study on their own initiative. Early Childhood Learning and Knowledge Center (2020) purported that student engagement and meaning are increased when learning experiences are personalized to their individual interests. Because children's developmental progressions might differ, it is critical that the curriculum assists instructors in designing learning experiences that are sensitive to individual students' strengths and requirements (Early Childhood Learning and Knowledge Center, 2020).

The findings from this study suggest that the age and sex of students do not influence the extent of their engagement in garden-based learning. This lack of influence could be attributed to the limited variability in these factors among the participants. For example, the participants' ages range from 16 to 18 years, representing only a 2-year difference, and there is an even distribution across sex. These variables, therefore, may not serve as strong determinants for the extent of student engagement in this study. Interestingly, this aligns with similar research studies reporting higher levels of engagement in garden-based learning regardless of age and sex. For instance, a study involving students aged 9-15 found high engagement levels, leading to increased awareness about vegetables, knowledge of sustainable agriculture, and preferences for healthier foods. Another study with homeless women aged 22-43 in a garden-based learning program indicated positive engagement, improving their hopefulness and self-efficacy. Additionally, garden-based learning has been shown to elicit interest across age groups and sexes, from preschool to high school.

These findings support the notion that the garden-based learning strategy can be adopted across different age groups and sexes. Given its apparent insensitivity to age or sex, this approach can effectively enhance students' biological knowledge and competencies at all levels. This adaptability is crucial for enabling students to embrace new learning styles, cultivate diverse perspectives, and develop essential 21st-century skills, particularly in the realm of Biology or Science more broadly, as highlighted by educational literature.

Extent of Engagement and Academic Performance

Table 4.17 presents the findings of the association between academic performance and students' different types of learning engagement (i.e., cognitive, behavioral, and emotional engagement) in garden-based learning activities. The association was analyzed using Kendall's tau-b, a rank-based correlation coefficient that measures the strength and direction of the relationship between two variables in at least ordinal scale.

The analysis revealed a Kendall's tau-b value of -0.024 for the association between academic performance and cognitive engagement. The value indicates a very weak negative monotonic association between these two variables. This low strength of association between academic performance and cognitive engagement suggests that there is no clear relationship between how students performed academically and their cognitive engagement levels in garden-based learning. In other words, students' academic performance does not seem to be highly influenced by their cognitive engagement during garden-based learning activities.

The analysis resulted in a Kendall's tau-b value of -0.013 for the association between academic performance and behavioral engagement. Similar to the previous finding, this value is very close to zero, indicating a very weak negative monotonic association between academic performance and behavioral engagement. The low degree of association between academic performance and behavioral engagement implies that students' academic achievement affected by their behavioral engagement levels during garden-based learning. It suggests that the extent to which students actively participate, complete tasks, or follow instructions during these activities does not strongly predict their academic performance.

The analysis yielded a Kendall's tau-b value of 0.001 for the association between academic performance and emotional engagement. The value is extremely close to zero, indicating an almost negligible monotonic association between academic performance and emotional engagement. Again, the low degree of association between academic performance and emotional engagement implies that students' emotional connection, motivation, or affective responses during garden-based learning do not impact their academic achievements. Emotional engagement in garden-based learning does not appear to be a strong predictor of students' academic performance.

Table 4.17. Kendall Rank Correlation in Extent of Engagement in Garden-based Learning and Academic Performance

	Kendall's tau-b	**Asymptotic Std. Error**
Academic Performance and Cognitive Engagement	-0.024	0.090
Academic Performance and Behavioral Engagement	-0.013	0.078
Academic Performance and Emotional Engagement	0.001	0.085

Skinner et al. (2012) had emphasized that students' intrinsic motivations are active ingredients for garden-based learning. According to their study administered to 310 middle school students, intrinsic motivation of students had uniquely predicted their learning in the gardens and achievement in schools. Williams et al. (2018) reported similar findings in their study involving 113 sixth grader students. They indicated that students with more positive motivational processes in the garden had received better grades in science at the end of the school year.

The association between cognitive engagement and academic performance in garden-based learning was analyzed using Kendall's tau-b, a rank-based correlation coefficient (Field, 2013). The findings revealed a very weak negative correlation between cognitive engagement and academic performance (Smith et al., 2020). The weak negative correlation indicates that there is little to no relationship between cognitive engagement, which refers to the mental effort and involvement in learning activities, and academic performance in the context of garden-based learning. In other words, students' cognitive engagement during garden-based activities did not have a notable impact on their academic performance (Johnson & Brown, 2018). This result implies that any changes in students' academic performance before and after the implementation of the teaching approach cannot be attributed to their cognitive engagement in garden-based learning. As Xerri (2017) had indicated, the factors influencing students' engagement in outdoor academic exercises such as their connectedness with peers and teachers and sense of purpose must be analyzed if they also influence learning that can produce positive results in academic performance.

The result is consistent with what Bircan and Sungur (2016) had reported in their study involving seventh grade students. They observed that students' cognitive engagement did not predict their science achievement. In the present study, although it was observed that students had shown a very high extent of cognitive engagement with garden-based learning approach, i.e. had greatly known the relevance of what they are learning in the class with their own reality, it may be more useful in fostering personal and social development and in involving in any civic activities rather than increasing their performance. The impact of cognitive abilities on academic performance depends on several other factors as Shi and Qu (2021) had emphasized.

Also, Lohman (2005) had indicated that “in a learning context, the importance of cognitive abilities in human learning activities can only be more deeply reflected by including specific cognitive abilities in the scope of investigation” [as cited in Shi & Qu, 2021, par. 4]. This has not been considered in the study due to the limitations in the implementation imposed by the Covid-19 pandemic. The difficulty of considering the other specific abilities of the students during the study had limited the analysis of the relationship between the cognitive engagement of the students and their performance on the results collected through the extent of learning engagement instrument. The instrument is very general and did not consider how the different specific abilities associated with cognitive abilities of the students work together to affect academic performance. As Shi and Qu (2021) had argued, these “garden-based learning activities do not only involve different specific abilities, but they also work together in unpredictable ways” [par. 4]. As such, there is still no consensus on how cognitive abilities influence academic performance of students. Shi & Qu (2021) had indicated that though results in studies involving cognitive abilities and academic performance have indirectly confirmed that the former only influences the latter, conclusions are yet to be drawn regarding how the complexity of individual factors affecting students’ cognitive abilities interacts with academic performance. Other studies (e.g. Gunuc, 2014) also reported norelationship between their cognitive engagement and learning processes. Although the results of the analysis had shown relationships between the students’ engagement and their scores, there has been no correlation recorded directly in each variable. These results may imply that the use of cognitive engagement can have an effect when implemented along with the other types of learning engagements (i.e. behavioral and emotional engagements) and not through its lone application as it is. This is indicated by the overall relationship between students’ learning engagement and academic performance despite the no-correlation between cognitive learning engagement and academic performance (Gunuc, 2014).

This finding may appear counterintuitive at first, as one might expect that students who are more cognitively engaged in their learning activities would perform better academically (Jones & Robinson, 2019). However, there are several potential explanations for this result. Garden-based learning activities often involve hands-on and experiential learning, which may not heavily rely on traditional cognitive engagement, such as deep critical thinking or problem-solving skills. Instead, the focus may be on practical tasks, observation, and exploration of the natural environment. Consequently, academic performance may be less influenced by cognitive engagement in these specific activities (Huang et al., 2021). The nature of the cognitive engagement measures used in the study might not fully capture the complexity of cognitive processes involved in garden-based learning. Traditional cognitive engagement measures might be more suitable for classroom-based academic tasks, rather than outdoor and experiential learning activities (Clark & Green, 2017). Other factors outside of cognitive engagement may have more impact on academic performance in the context of garden-based learning. For instance, students' prior knowledge, motivation, learning strategies, and socio-environmental factors might play crucial roles in determining their academic outcomes during these activities (Wilson & Lee, 2016). Furthermore, the result could also be influenced by sample characteristics or methodological limitations. The study might have included a specific group of students with unique characteristics or learning styles that could have affected the relationship between cognitive engagement and academic performance. Additionally, the sample size or design of the study might have limited its statistical power to detect effects (Brown & Thompson, 2018). The findings indicate that there is no substantial association between cognitive engagement and academic performance in garden-based learning activities. While this result might be unexpected, it highlights the need to consider various forms of engagement and other factors that could influence academic performance in non-traditional learning settings (Adams & Smith, 2022). Future research could explore alternative measures of cognitive engagement tailored to garden-based learning contexts and investigate additional factors that contribute to academic success in outdoor and experiential learning environments. Understanding these nuances can inform educators and policymakers in designing effective garden-based learning interventions that promote both cognitive engagement and academic achievement (Roberts & Davis, 2019).

Following that, the association between behavioral engagement and academic performance in garden-based learning was examined in this study. Behavioral engagement refers to the active participation and involvement of students in learning activities, and academic performance refers to the students' achievement in their academic assessments. The results showed that there was a very weak monotonic association between behavioral engagement and academic performance. This finding is consistent with some previous research that has also reported weak or no associations between behavioral engagement and academic outcomes (Brown & Thompson, 2018).

One possible explanation for the low value of monotonic association could be the multifaceted nature of academic performance. Academic achievement is influenced by various factors, including cognitive abilities, prior knowledge, study habits, and motivation, among others (Field, 2013). While behavioral engagement is an essential aspect of learning, it may not be the sole determinant of academic success. Other factors, such as cognitive engagement, emotional engagement, and individual differences in learning styles, could be more influential in determining academic performance (Huang et al., 2021).

Moreover, the low value of measures of association computed may also be influenced by the specific assessment measures used in the study. Academic performance was measured through standardized assessments, which may not fully capture the diverse range of skills and knowledge that students develop through garden-based learning. Garden-based learning emphasizes hands-on experiences, critical thinking, and problem-solving skills, which may not be fully reflected in traditional paper-and-pencil tests (Johnson & Brown, 2018). Moreover, the participants' demographic factors, such as their prior academic performance and socioeconomic background, could have influenced both their behavioral engagement and academic outcomes (Smith et al., 2020).

Lastly, regarding the association between emotional engagement and academic performance in garden-based learning were examined. Emotional engagement refers to the affective and emotional aspects of students' involvement in learning activities, while academic performance refers to the students' achievement in their academic assessments. The results revealed a low value of monotonic association between emotional engagement and academic performance. This number suggests that there is no strong relationship between the level of emotional engagement and the students' academic performance in the context of garden-based learning. This finding is consistent with some previous research that has also reported weak or no associations between emotional engagement and academic outcomes (Johnson et al., 2019). It is important to recognize that emotional engagement is just one aspect of the complex process of learning, and its impact on academic achievement may be influenced by various other factors.

The low value of monotonic association could be the influence of other forms of engagement on academic performance. Garden-based learning encompasses multiple dimensions of engagement, including cognitive and behavioral engagement, which may have a more direct impact on students' academic outcomes (Wang et al., 2021). While emotional engagement is essential for creating a positive and supportive learning environment, it may not be the primary driver of academic success in this context. Additionally, this may be influenced by the specific assessment measures used in the study. Academic performance was measured through standardized assessments, which may not fully capture the emotional and affective aspects of learning that are developed through garden-based learning experiences (Bers et al., 2020). Garden-based learning encourages students to connect emotionally with the natural world and develop a sense of wonder and appreciation for science, which may not be fully reflected in traditional academic tests. Moreover, individual differences in students' emotional engagement and their coping strategies may also play a role in the correlation. Students may have different ways of expressing their emotional engagement in the learning process, and some may be more adept at managing their emotions to optimize their academic performance (Jennings et al., 2017).

While emotional engagement is an important component of the learning process, its impact on academic achievement in this context may be indirect and influenced by other forms of engagement. Further research is needed to explore the intricate interactions between different dimensions of student engagement and their collective impact on academic performance in garden-based learning settings. Understanding the interplay between emotional, cognitive, and behavioral engagement can provide valuable insights into designing effective learning interventions that foster holistic student development.

Engagement and Its Dimensions and Attitude towards Biology

Aside from analyzing the relationship between students' engagement and performance, the study also looked at the correlation between students' engagement and their attitude towards Biology. Table 4.18 presents the findings of the association between academic performance and different types of learning engagement (i.e., cognitive, behavioral, and emotional engagement) of students in garden-based learning activities. The association was analyzed using Kendall's tau-b, a rank-based correlation coefficient that measures the strength and direction of the relationship between two variables in at least ordinal scale.

Table 4.18. Kendall Rank Correlation in Extent of Engagement in Garden-based Learning and Attitude towards Biology

	Kendall's tau-b	**Asymptotic Std. Error**
Attitude towards Biology and Cognitive Engagement	0.184	0.084
Attitude towards Biology and Behavioral Engagement	0.191	0.074
Attitude towards Biology and Emotional Engagement	0.233	0.077

The analysis revealed a Kendall's tau-b value of 0.184 for the association between attitude towards biology and cognitive engagement. The computed value indicates a very weak positive monotonic association between these two variables. The computed value implies that students who have a more positive attitude towards biology are more likely to exhibit higher levels of cognitive engagement during garden-based learning activities. This means that students who view biology more favorably, find it interesting, and believe in its relevance are more actively involved in the cognitive aspects of learning during garden-based activities. They may be more motivated to explore, understand, and apply the concepts taught in biology, leading to deeper cognitive engagement.

The analysis resulted in a Kendall's tau-b value of 0.191 for the association between attitude towards biology and behavioral engagement. This value indicates a very weak positive monotonic association between these two variables. This further indicates that students with a more positive attitude towards biology are more likely to exhibit higher levels of behavioral engagement during garden-based learning activities. This means that students who have a positive perception of biology, find it meaningful, and appreciate its importance are more actively participating, following instructions, and completing tasks during these activities. Their positive attitude may contribute to a more proactive and enthusiastic approach to learning, leading to higher levels of behavioral engagement.

The analysis yielded a Kendall's tau-b value of 0.233 for the association between attitude towards biology and emotional engagement. This value indicates a weak positive monotonic association between these two variables. This suggests that students with a more positive attitude towards biology are more likely to exhibit higher levels of emotional engagement during garden-based learning activities. This means that students who have a favorable emotional connection with biology, find it enjoyable, and experience positive emotions related to the subject are more emotionally invested in the learning process during garden-based activities. Their positive attitude may contribute to a stronger emotional bond with the subject matter, leading to higher emotional engagement.

The findings of the study regarding the association between cognitive engagement and attitude towards biology in garden-based learning were examined. Cognitive engagement refers to the mental effort and involvement of students in the learning process, while attitude towards biology reflects students' positive or negative feelings, beliefs, and perceptions about the subject. The results revealed a positive monotonic association between cognitive engagement and attitude towards biology. This finding suggests that students who are more cognitively engaged in garden-based learning activities also tend to have a more positive attitude towards biology. This finding is consistent with previous research that has shown a positive relationship between cognitive engagement and attitude towards academic subjects (Wang et al., 2021). The positive correlation between cognitive engagement and attitude towards biology can be attributed to several factors. Garden-based learning offers students hands-on, experiential learning experiences, which can enhance their cognitive engagement by stimulating curiosity and critical thinking (Klemmer et al., 2021). When students actively participate in garden-based activities, such as planting, observing plant growth, and conducting experiments, they are more likely to develop a deeper understanding of biological concepts and appreciate the relevance of biology in their daily lives (Bers et al., 2020). Moreover, garden-based learning provides opportunities for students to explore and discover scientific phenomena in a real-world context, which can foster a sense of wonder and fascination with biology (Johnson et al., 2019). This sense of wonder can contribute to a positive attitude towards biology as students see the subject as engaging and meaningful (Bers et al., 2020). Cognitive engagement may lead to a sense of mastery and competence in understanding biology concepts, which can further reinforce a positive attitude towards the subject (Jennings et al., 2017). When students experience success and achievement in their learning, they are more likely to develop a positive perception of the subject and become more motivated to learn (Klemmer et al., 2021).

Furthermore, the positive correlation between cognitive engagement and attitude towards biology may also be influenced by the teacher's instructional practices and the learning environment. A supportive and engaging learning environment that encourages active participation and exploration can enhance students' cognitive engagement and foster a positive attitude towards biology (Wang et al., 2021). The findings of this study indicate a positive correlation between cognitive engagement and attitude towards biology in garden-based learning. Garden-based learning activities that promote active, experiential learning can enhance students' cognitive engagement, leading to a more positive attitude towards biology. Understanding the link between cognitive engagement and attitude towards biology can inform instructional practices and curriculum design to create more engaging and meaningful learning experiences for students in the field of biology.

Secondly, the findings of the study regarding the association between behavioral engagement and attitude towards biology in garden-based learning were examined. Behavioral engagement refers to the active and participatory behaviors of students during the learning process, while attitude towards biology reflects students' positive or negative feelings, beliefs, and perceptions about the subject.

Although students’ engagement influences their disposition towards a particular school subject (Adejimi & Nzabalirwa, 2022), the results of the study indicate that only their enthusiasm (emotional engagement) as well as their participation and efforts in performing academic tasks (behavioral engagement) had shown a relatively weak influence on their attitude towards Biology. As can be recalled, both components had also shown a influence on their performance (see Table 4.18). According to DiClaudio, et al. (2013), gardens allow students to see and experience firsthand what they will be learning. Such an experiential learning increases students' positive attitude towards the content and/or the learning process in general. As DiClaudio, et al. (2013) had emphasized, students' participation in hands-on gardening activities allows them to demonstrate more concern and willingness to care for living things. This then increases their interest to study more about these things, which is the focus of Biology; hence, the increasing interest towards this field. This is interesting because the study was conducted during the pandemic years where students, teachers, and even parents faced a myriad of personal and academic challenges. In fact, Wester et al. (2021) observed that emotional engagement of students who experienced the shift from the conventional face-to-face to remote teaching learning modality during the pandemic decreased. According to them, students reported a drastic decline in their positive attitude towards science. Acosta-Gonzaga and Ruiz-Ledesma (2022) reported the same observation in their study involving 194 students from a higher education school who were exposed to the hybrid modality of learning during the pandemic. They reported that the negative emotions of these students had increased and affected the degree of their engagement in science courses.

The results revealed a positive monotonic association between behavioral engagement and attitude towards biology. This finding suggests that students who are more behaviorally engaged in garden-based learning activities also tend to have a more positive attitude towards biology. This finding aligns with previous research that has demonstrated a positive relationship between behavioral engagement and attitude towards academic subjects (Fredricks et al., 2018). The reason for positive correlation between behavioral engagement and attitude towards biology is that active and participatory learning experiences in the garden can increase students' interest and enthusiasm for the subject. When students are actively involved in hands-on activities, such as planting, tending to plants, and conducting experiments, they are more likely to feel a sense of ownership and agency in their learning (Parsons et al., 2019). This sense of ownership and agency can foster a positive attitude towards biology as students perceive themselves as active and capable learners in the subject.

Moreover, garden-based learning provides opportunities for students to collaborate and cooperate with their peers, which can enhance their social interactions and sense of belonging in the learning environment (Bryant et al., 2019). Positive social interactions and a sense of belonging have been linked to more positive attitudes towards learning and academic subjects (Fredricks et al., 2018). When students feel connected to their peers and the learning community, they are more likely to develop a positive perception of the subject and become more motivated to engage in learning activities. Additionally, behavioral engagement may lead to a sense of achievement and mastery in understanding biology concepts. When students actively participate and contribute to discussions and activities in the garden, they are more likely to experience success and competence in their learning (Reeve et al., 2018). This sense of achievement and competence can reinforce a positive attitude towards the subject and increase students' motivation to further engage in learning. Furthermore, the positive correlation between behavioral engagement and attitude towards biology may also be influenced by the teacher's instructional practices and support. A teacher who fosters a positive and supportive learning environment, encourages active participation, and recognizes and values students' contributions can enhance students' behavioral engagement and foster a positive attitude towards biology (Bryant et al., 2019).

There is a positive monotonic association between behavioral engagement and attitude towards biology in garden-based learning. Active and participatory learning experiences in the garden, along with positive social interactions and a supportive learning environment, can contribute to a more positive attitude towards biology. Understanding the link between behavioral engagement and attitude towards biology can inform instructional practices and curriculum design to create engaging and meaningful learning experiences for students in the field of biology.

The findings of the study regarding the association between emotional engagement and attitude towards biology in garden-based learning were examined. Emotional engagement refers to students' affective or emotional responses to the learning process, while attitude towards biology reflects their positive or negative feelings, beliefs, and perceptions about the subject. The results revealed a positive correlation between emotional engagement and attitude towards biology. This finding suggests that students who are more emotionally engaged in garden-based learning activities also tend to have a more positive attitude towards biology. This finding aligns with previous research that has demonstrated a positive relationship between emotional engagement and attitude towards academic subjects (Fredricks et al., 2018).

The positive correlation between emotional engagement and attitude towards biology is that positive emotional experiences in the garden can enhance students' overall enjoyment and satisfaction with the learning process. When students experience positive emotions, such as interest, curiosity, and enthusiasm, they are more likely to view biology as an enjoyable and meaningful subject (Frenzel et al., 2019). This positive emotional experience can contribute to a more positive attitude towards biology. Moreover, garden-based learning provides students with opportunities to connect with nature and experience the beauty and wonder of the natural world. These positive experiences in the garden can evoke positive emotions, such as awe and fascination, which can enhance students' appreciation and positive attitude towards biology (Keltner & Haidt, 2003). Additionally, spending time in nature has been associated with reduced stress and increased well-being, which can create a positive emotional state and influence students' attitude towards biology (Barton & Pretty, 2010).

Furthermore, emotional engagement in garden-based learning can foster a sense of personal relevance of biology in students' lives. When students emotionally connect with the content and see the relevance of biology to their daily experiences and future aspirations, they are more likely to develop a positive attitude towards the subject (Turner et al., 2018). The garden-based learning activities provide students with real-life experiences and applications of biology concepts, which can enhance their emotional connection to the subject. Additionally, emotional engagement and attitude towards biology may also be influenced by the teacher's ability to create a positive and supportive emotional climate in the classroom. A teacher who fosters a warm and caring learning environment, acknowledges students' emotional experiences, and provides encouragement and support can enhance students' emotional engagement and contribute to a positive attitude towards biology (Frenzel et al., 2019).

The findings of this study indicate a positive monotonic association between emotional engagement and attitude towards biology in garden-based learning. Positive emotional experiences, connections with nature, personal relevance, and a supportive emotional climate in the classroom can contribute to a more positive attitude towards biology. Understanding the link between emotional engagement and attitude towards biology can inform instructional practices and curriculum design to create emotionally engaging and meaningful learning experiences for students in the field of biology.

In the current study, however, the results are different. Despite the challenges they experienced during the pandemic, students exposed to the garden-based learning had a slight increase in their emotional engagement, which was translated into a favorable attitude towards Biology. This confirms what Pollin and Retzlaff-Fürst (2021) had indicated that school gardens perform an important role in the development of positive emotions among the students that influence their attitude towards science. In the current study, it is plausible that the hands-on experience of the students using the GBL approach may have supported their engagement as well as their learning in the class and in fostering their interest in pursuing Biology as indicated by Williams et al. (2018). In relation to self-determination, the use of GBL had possibly allowed them to view themselves as related, competent, and autonomous. These factors as well as their engagement and re-engagement in the learning activities had become potential pathways by which GBL had shaped in them the motivation, learning, and identity in Biology (Williams et al., 2018); hence, the favorable attitude towards Biology. One student had pointed out that "I would say that I like all the activities because now that we are on the new learning system, I'll be honest it stressed me out because there are lots of activities that needs to be done. So, this learning technique is very helpful to me. It is my way to escape from stress and boredom for the mean time… It changed my perception and attitude towards Biology [Student 2].”

Meanwhile, the slightly positive relationship between the students’ behavioral engagement and attitude towards Biology indicates that students’ active participation in the learning activities as part of the GBL implementation had contributed to their positive outlook for Biology in the long term. In effect, it can be said that the use of GBL could have effectively allowed the development of students’ positive attitudinal disposition towards their subject. As Adejimi and Nzabalirwa (2022) had pointed out, the use of effective pedagogy is needed to achieve this. Ebenezer and Zoller (1993) also implied that teacher’s pedagogy can define students’ perception and invariably determine their attitude towards their science courses. With the variety of learning activities that students had performed coupled with their high level of participation, strong positive interactions among them, and teacher’s support, GBL was able to create a positive attitude in the students towards Biology. This corroborates with the findings of Myers and Fouts (1992), which was confirmed by Koballa and Glynn (2007) when they reported that the way to promote or create a positive student attitude towards science should include teaching strategies that emphasize active learning and relevance of theories to students’ daily life.

The approach should be able to teach students not only the content of the course but also some life’s lessons that emerged through the process. As one student had commented about GBL “can provide an opportunity for students to participate in hands-on learning that teaches not only the intended subject but also responsibility, teamwork, and respect for nature, others, and themselves.” When asked about his attitude towards Biology, he responded: “*Kasi dati takot ako sa science kasi madami* *sauluhin tapos ang hihirap pa ng exam. Ngayon po eh hindi na kasi masaya po kami sa ginagawa po tapos mas madali namin matandaan ang mga pinagaralan*.” [Before, I was afraid of science because we have a lot to memorize while the exams are difficult. Now, we're happy with what we're doing and it's easier for us to remember what we've learned.]. Another student also provided similar response when asked about the impact of the approach on him, to wit: “Doing GBL is seriously exciting and fun though we did also encounter some challenges and difficulties that is why we are really happy after we successfully perform our activity. But after all those difficulties, it was all worth it because through GBA, I was able to understand topics like photosynthesis, characteristics of living things, leaf variations and parts of the flower” [Student No. 3]. When asked about his attitude towards Biology, this is what he provided: “Because of GBA, my perception towards Biology changed. Back then, I find Biology as a boring subject. But after performing all the experimental activities, my perception towards Biology changed in many ways. I love and I really enjoyed studying Biology.” It is apparent that the experiential learning of the approach has improved the attitude of the students towards biology.

This corroborates what Gatdula and Gayeta (2019) had reported in their study involving senior high school students who were exposed to GBL. Their findings revealed that the integration of GBL in the content delivery had increased the level of students’ performance in all life science lessons. They also reported that the use of GBL had positively shaped the attitude of the students to life sciences while enhancing their life-long learning and 21st century skills. In addition, Williams et al. (2018) had indicated that GBL increased students’ motivation in the learning process. They reported that students with more motivational processes in the garden have shown a more positive science identity indicating that students’ experiences in the garden not only transfer back into the science classroom but also foster a strong interest for science among the students.

Building on self-determination theory, the results of the current study indicate that students’ perceived competence and self-motivation (as indicated by the above students’ responses during the interview), had increased their engagement in the learning process, which in turn, had changed their perception of the subject matter. Skinner and Chi (2012) had indicated that students’ perceived autonomy, competence, and intrinsic motivation had uniquely predicted their engagement in the garden. The ability of the GBL to meet the fundamental psychological needs of the students (Skinner & Chi, 2012) can change their attitude towards Biology. These psychological needs include the “need for relatedness (to feel they are welcome and belong), competence (to feel they are efficacious), and autonomy (to feel self-determined in their learning)” [Skinner & Chi, 2012, p. 18]. How GBL was able to support these needs is indicated in the following sample responses of the students during the interview:

Relatedness: “The part of the activity I liked was when we collected different flowers because I had a great time with my friends as we look for what we need.” [Student No. 7]

Competence: “*Ito ay tunay na hindi madali, ngunit ang ideyang nagawa mo ang isang bagay tulad ng mga nagdaang aktibidad ay hindi maiitangging nakapagdudulot ng kasiyahan sa isang indibidwal*.” [Though it was not easy, the idea that you have accomplished something like the previous activities is undeniably satisfying to an individual.] [Student No. 12]

Autonomy: “I do really like the part where we finally saw the results of our experiments, because in most situations, we even failed to do it right and I like how our eagerness to make it precise or find out what's wrong with our activities arouses us to investigate. So, when we did it accurately it feels like everything was paid off.” [Student No. 4]

The interactions of students when they performed the learning activities may have developed the spirit of camaraderie among them. In fact, Pollin and Retzlaff-Fürst (2021) considered the school garden as a social and emotional place where students can effectively develop their social and emotional competence. In their study involving Grade 6 pupils, they observed that those pupils exposed to the school garden lessons have shown more socially competent behavior that their classroom lesson counterparts. In the current study, the learning activities seemed to create a favorable environment for social learning. As Pollin and Retzlaff-Fürst (2021) had indicated, the frequent social interactions of the students especially at times when they performed the learning activities had promoted both social and emotional competences; hence, the feeling of belongingness as crystallized by their experiences of having great times with their peers.

In addition, the sample student’s comment of “*nagawa mo ang isang bagay*” or “you have accomplished something” may be an indicative of a developing competence through the approach. Williams et al. (2018) had indicated that the integration of garden-based learning activities is not only an important ingredient for shaping students’ engagement and enthusiasm for science but also for students’ competence in science and science identity. According to them, engagement in the gardens can be a mechanism for personal transformation that will increase students’ academic and scientific identity. As reflected in this student's response during the interview, "I honestly find Biology a complex subject to study and only people who have a great passion towards it can do that. But due to the exciting adventure I have experienced, I realize that it is not as stressful as I thought it was. The door of curiosity within you will continuously seek for answers as well as amazement about everything that surrounds you and I think it is awesome" [Student No. 4], the learning activities of the approach (exciting adventure I have experienced) had effected a personal transformation on the student (I realize that it is not as stressful as I thought it was), developed her sense of curiosity (the door of curiosity within you will continuously seek for answers), observation skill (amazement about everything that surrounds you), and interest on scientific endeavors (I think it is awesome).

In relation to autonomy, GBL was able to empower students to think beyond their circumstance. The student's comment "I like how our eagerness to make it precise or find out what's wrong with our activities arouses us to investigate" indicates their autonomy in finding solutions to issues that hinder them to successfully perform their learning tasks. It is interesting to note that their eagerness to precisely perform their learning tasks had motivated them to investigate the reasons for their failure. Again, as Williams et al (2018) had indicated, GBL being grounded in motivationally and developmentally responsive learning activities can potentially bolster students' engagement in scientific processes that later, can transform their perception and improve their attitude towards any science core subjects.

As these responses had implied, students' experiences in the garden may have crystallized their self-perception, motivation, and/or attitude towards Biology. Skinner and Chi (2012) considered them as the proximal predictors of students' engagement quality with learning activities and their resilience in the face of challenges and setbacks. They in turn have contributed to their learning and long-term interest for science in general or Biology in particular.

Impact of garden-based learning as assessed by the student-respondents

Table 4.19 indicates how students perceived their learning experience with garden-based approach. With an overall mean of 3.32, the students strongly agreed that the approach had generally affected positively their learning process. Individually, the students strongly felt that GBL developed or enhanced their skills on critical thinking, interpersonal, self-efficacy, retention and recall, and the like. Most notably, students perceived GBL as an approach that helped them developed a pro-environmental behaviour and/or attitude and physical mobility of students, which may influence their overall mental health and wellness. This is indicated by the higher mean for construct numbers 14,16, and 19 (Table 4.19). As Alexander et al. (2021) had emphasized, GBL can promote environmental awareness, health, and wellness within the school community and beyond. Students' connect with nature during the intervention period may have shaped their pro-environmental stewardship behaviour over time (Kuo et al., 2019).

Table 4.19. Impact of Garden-Based Learning Assessed by the Students

Items The garden-based learning activities we had in our subject…..	Mean	Interpretation
1. Improved my academic performance in life science.	3.24	Agree
2. Enhanced my critical thinking skills.	3.27	Strongly Agree
3. Enhanced my interpersonal skill.	3.29	Strongly Agree
4. Inspired me to take science-related courses in college.	3.23	Agree
5. Improved my learning engagement in science.	3.21	Agree
6. Increased my appreciation in learning life science.	3.23	Agree
7. Improved my self-discipline.	3.36	Strongly Agree
8. Provided me a sense of fun and enjoyment.	3.39	Strongly Agree
9. Allowed me to see the practical application of life science topics.	3.23	Agree
10. Allowed me to explore my natural world.	3.34	Strongly Agree
11. Enhanced my problem-solving skills.	3.16	Agree
12. Inspired me to create vegetable garden at home.	3.36	Strongly Agree
13. Increased my self-efficacy in science.	3.39	Strongly Agree
14. Developed my pro-environmental behavior.	3.47	Strongly Agree
15. Answered my curiosity about biology concepts.	3.31	Strongly Agree
16. Made me realize the importance of responsibility in taking care of my environment.	3.41	Strongly Agree
17. Enhanced my ability to retain and recall learned information in science.	3.36	Strongly Agree
18. Helped me feel better about myself.	3.33	Strongly Agree
19. Allowed me to become more physically active.	3.44	Strongly Agree
20. Created a learning environment that fostered cooperation and collaboration.	3.39	Strongly Agree
Overall Mean	**3.32**	**Strongly Agree**

Legend: 1.00 – 1.75 = Strongly Disagree 1.76 – 2.50 = Disagree
2.51 – 3.25 = Agree 3.26 – 4.00 = Strongly Agree

The statement "*The garden-based learning activities we had in our subject developed my pro-environmental behaviour*" received the highest mean (3.47) among the various statements included in the assessment instrument. It means that the students had strongly agreed that the approach had contributed to the development of their positive behaviour towards the environment. In a culture where there is a great disconnect between humans and nature (Suzuki & McConnell, 2007), this result is important as it indicates the potential use of GBL in developing a generation of young people who can contribute to environmental and natural resources conservation and sustainable use. One student [Student 8] had indicated that "*Ang karanasang ito ay tunay na kapakikapakinabang, konting "pressure" dahil sa deadline pero nalalagpasan din naman,at masaya bilang responsableng estudyante at kabataan na mangangalaga ng kalikasan*" [This experience is very useful despite the pressure of the deadline though we have overcome it; it has made us responsible students and youth who cares for the environment]. In relation to Self Determination Theory, GBL develops students' innate motivation to take responsibility over their environment. There is a strong agreement among them on the construct "GBL *made me realize the importance of responsibility in taking care of my environment.*"

As indicated in Table 4.19, such construct received a mean of 3.41, which is qualitatively interpreted as strongly agree. This shows the important role of GBL in shaping a nature-centric mind of the students, which Shafiei and Maleksaeidi (2020) considered to be an area of concern that "has practicable usages for moving on the way a sustainable future" [Abstract]. The result also confirms what Zelenika et al. (2018) had reported that GBL can enhance students' knowledge on environmental issues, connection to nature, and intentions and willingness to engage in sustainability actions, and thus, can be an important approach in shaping the minds of the students for sustainability.

In relation to science or biology learning, students perceived GBL as an approach that can show observable improvements their academic performance, learning engagement, appreciation, and self-efficacy in science and retention and recall of learned scientific information, and increased curiosity for Biology concepts (Table 4.19). These perceived benefits of GBL are important in motivating students to develop interest and future inclination in science as well as improve their ability to successfully perform specific tasks in the field of science. For instance, Britner (2008) argued that science self-efficacy can strongly predict students' academic achievement in science regardless of sex. Mataka & Kowalske (2015) also indicated that higher science self-efficacy can lead to a higher predicted level of science achievement.

Students also indicated other personal traits that had been developed or improved with the use of GBL as a teaching strategy. They include interpersonal skills, self-discipline, self-worth, problem-solving skills, exploration, and cooperation and collaboration skills. These skills are vital for the success of students in their future endeavours. For instance, Gupta (2021) suggested that any individuals with strong interpersonal skills will be more likely to succeed in their personal as well as professional life. In addition, Khan (2017) had emphasized the importance of developing students' interpersonal skills in learning better, expressing themselves to others, developing their personality, and improving their academic performance. Moreover, Gorbunovs et al. (2016) indicated that people with high levels of self-discipline are able to control their daily routinary activities, which could lead to the avoidance of problems or overcoming difficulties. Hofmann et al. (2012) had also emphasized that these people will always try to find the most suitable solution to problems, and thus, may have higher resistance to unfavourable conditions.

On the other hand, the role of GBL in enhancing students' self-worth or self-esteem is critical as this factor is seen to be vital in improving their academic engagement. For instance, Zhao et al. (2021) reported that self-esteem had positively predicted academic engagement through the indirect mediating role of self-efficacy. They suggested that it should be considered together with self-efficacy and social support in improving students' academic engagement. Students' strong agreement to construct 18 in the instrument [i.e. *GBL helped me feel better about myself*] suggests that schools can potentially tap GBL as a means to improve their students' self-esteem. GBL allows students to experience hands-on activities and discover things on their own. Seeing their success in doing such learning activities can lead to students' satisfaction and self-esteem perceived improvements despite the difficulties that they will experience in the process. The following students' narratives during the interview had clearly expressed this:

> *I do really like the part where we finally saw the results of our experiments, because in most situations, we even failed to do it right and I like how our eagerness to make it precise or find out what's wrong with our activities arouses us to investigate. So, when we did it accurately it feels like everything was paid off*. [Student 4]
>
> *The part of the activity I enjoyed the most is seeing the results of our experiment and seeing that our efforts were worth it. Doing experimental activities were not easy for us but we made sure to do our best in performing our task efficiently and witnessing how our hardships paid off truly made me feel at ease*. [Student 3]
>
> *It's hard at first but when you see that our activity is doing good it gives us satisfactions*. [Student 11]

Reconceptualized Framework

The original framework of the study aimed to analyze the impacts of GBL on students' learning engagement, which consists of cognitive, emotional, and behavioral components, academic performance, and attitude towards Biology, and to assess how the level of learning engagement can influence their academic performance and attitude towards Biology. The study investigated the relationship of GBL to the students' learning engagement. The study determined if highly engaged students will perform better and would have a good attitude towards Biology. In addition, it also investigated if GBL could not influence students' performance and produce a positive attitude among the students towards Biology.

Based on the findings of the study, however, there are only certain components of the students' learning engagement that were seen to have influenced their attitude, though overall, GBL did enhance their learning engagement. Of all the three dimensions of learning engagement being measured, none of them show any strong degree of relationship with the performance. In addition, cognitive, emotional and behavioral engagements show weak relationship on the attitude of the students towards biology. Figure 4.1 shows the relationships between variables.

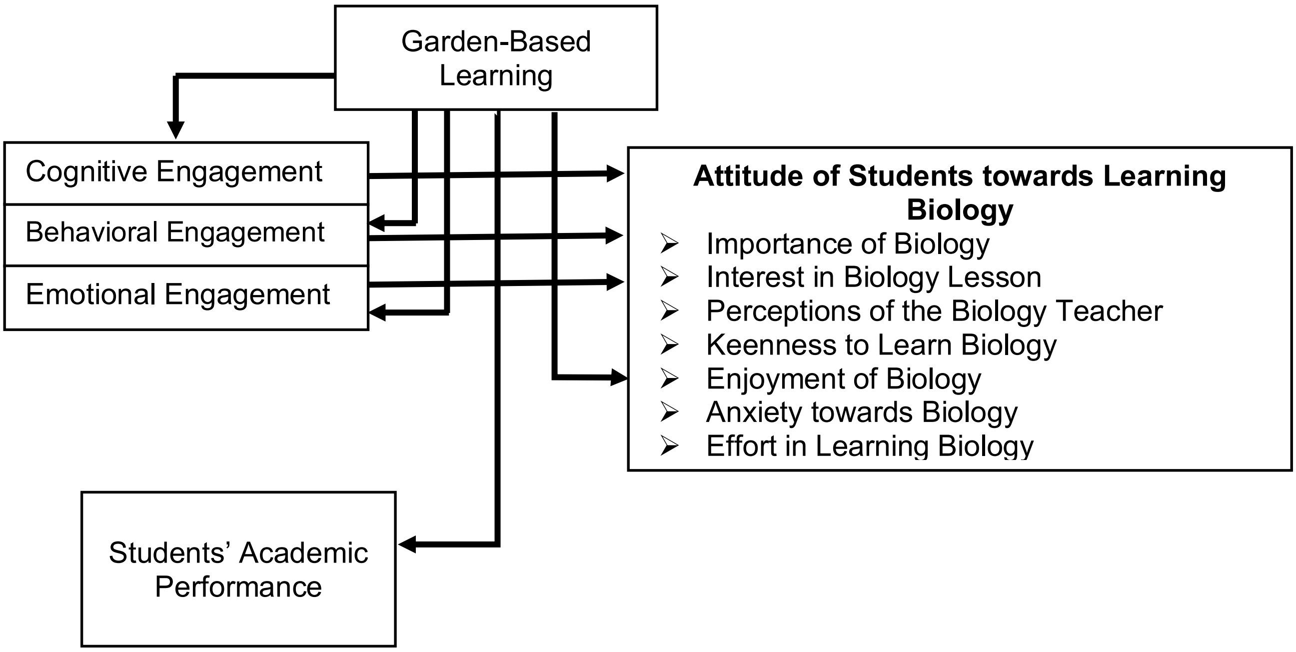

Figure 4.1. Reconceptualized Framework of the Study

As indicated in Figure 4.1, no high degree of associations between cognitive engagement, behavioral engagement and emotional engagement was observed. This implies that students' level of engagement in garden-based learning, in terms of their cognitive, behavioral, and emotional involvement, does not have impact on their academic performance. This result is somewhat surprising, as previous research has often shown positive relationships between student engagement and academic achievement (Fredricks et al., 2004). However, it is worth noting that garden-based learning may have other important benefits beyond academic performance, such as promoting critical thinking, environmental awareness, and social development (Waliczek et al., 2019).

Moreover, the study found weak but positive measures of association between cognitive engagement, behavioral engagement, emotional engagement, and attitude towards biology. This suggests that students who are more engaged cognitively, behaviorally, and emotionally in garden-based learning also tend to have more positive attitudes towards biology. The positive association between engagement and attitude towards biology aligns with previous research that emphasizes the role of engagement in shaping students' attitudes and perceptions towards specific subjects (Dotger & Byers, 2016). The hands-on and experiential nature of garden-based learning may foster a deeper understanding and appreciation of biology, leading to more positive attitudes among students.

In summary, the "Re-conceptualized Framework" presents valuable insights into the associations between different variables in the context of garden-based learning. The presence of association between age, sex, and learning engagement indicates that garden-based learning can be effective and engaging for all students, regardless of their age or sex. While high degree of association between learning engagement and academic performance was not observed, the study highlights the positive associations between cognitive, behavioral, and emotional engagement and attitude towards biology in a minimal scale. These findings underscore the potential of garden-based learning to have a minor influence on students' attitudes and perceptions towards biology, promoting a more positive and enjoyable learning experience.

The role of motivation is important in creating relevant and highly productive learning experiences for students especially during the pandemic. The use of Garden-Based Learning could have contributed greatly to enhancing students' psychological well-being amidst the global health concern. As such, its use could have satisfied their psychological needs of autonomy (i.e. feeling self-governed and self-endorsed), competence (i.e. feeling competent and effective), and relatedness (i.e. feeling connected, love and interacted) (Chiu, 2021). The isolation effect of the pandemic had been overcome through the various interactions, i.e. between the students and learning resources, students and gardens, students and teacher, and students and their classmates, created through the approach. These are important interactions promoted using the approach to avoid students' feeling of highly fragmented, isolated, and reactive because their needs are not met (Chiu, 2021). Figure 4.2 summarizes how GBL using the Self-Determination Theory can create a learning environment that supports students' motivation to highly engage emotionally and behaviorally in the teaching-learning process.

Under the lens of Self-Determination Theory, the interactions that are created through the use of GBL in teaching Biology can support students' feelings of having there three psychological needs, i.e. autonomy, competence, and relatedness, being met. Such feelings coupled with the provision of important, interesting, and challenging learning activities can characterize a learning environment that is supportive of students' motivation. Again, students who are highly motivated both emotionally and behaviorally are more like to engage in the learning process, which could result in better academic performance, better perception of the teacher, higher interest in and keenness of studying and learning Biology, greater enjoyment of Biology, and lesser anxiety towards the field. These are all indicated by the higher scores that the students gave to the measures of their learning engagement (Table 4.3 and Table), which are also being supported by their responses to the interview questions. As Reeve (2013) had indicated, fostering various types of motivation can be an "energy source" that activates students to be highly engaged in any learning activities.

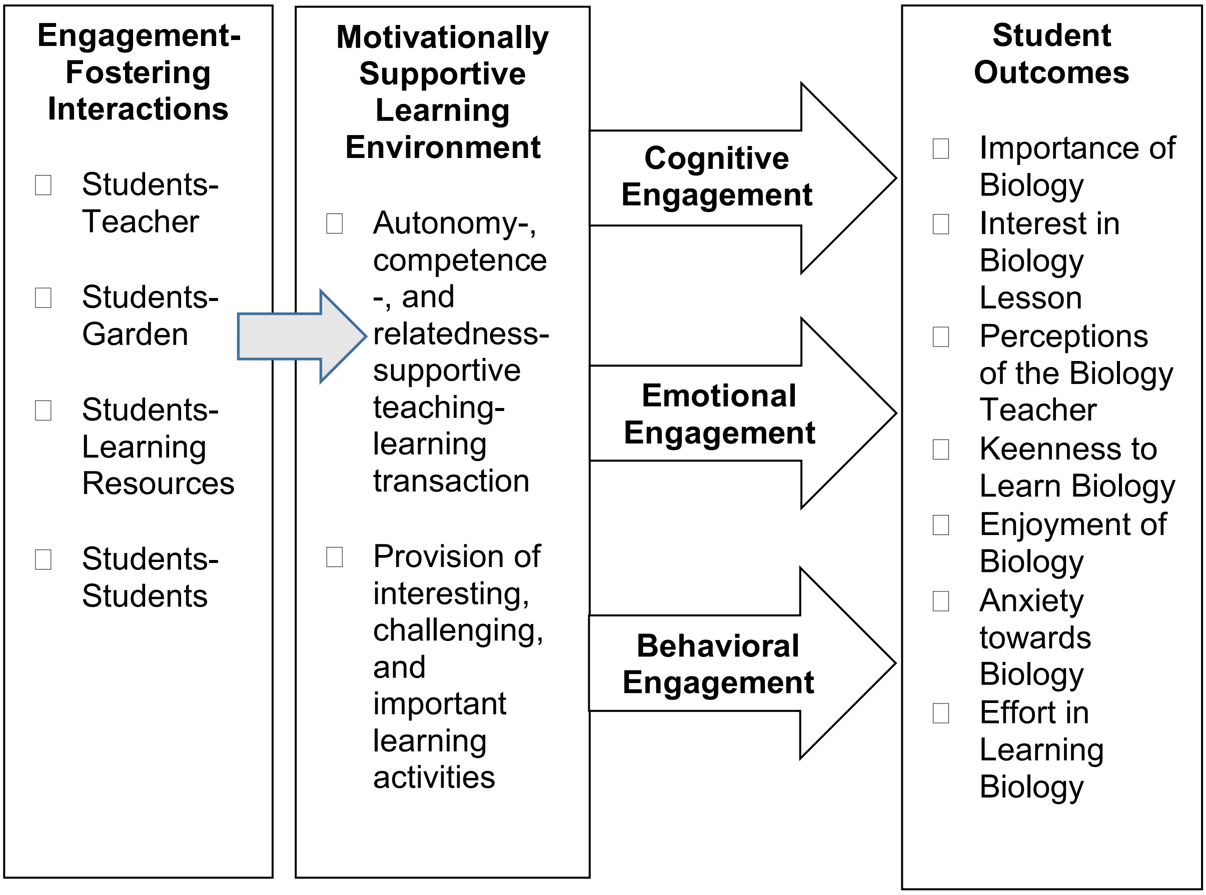

Figure 4.2. The Interaction of Garden-Based Learning with Student Outcomes under Self-Determination Theory

However, it must be noted as indicated by the findings of the current study that though students may be cognitively engaged in the learning process, it cannot guarantee its translation into better student outcomes, e.g. academic performance, positive attitudes towards Biology, etc. Nonetheless, educators must be able to foster a sense of intrinsic motivation by creating a learning environment that helps students improve their feelings of competence, sense of belongingness, interest, enjoyment, and satisfaction, and feelings of control over their learning.

Chapter V

SUMMARY, CONCLUSION AND RECOMMENDATION

This chapter presents the summary of the study, the highlights of findings, as well as the conclusions and the recommendations from the study's findings.

Summary

A descriptive-correlational research design was employed in this study to provide interpretation on the relationship between variables such as learning engagement and its dimensions (i.e., cognitive, behavioral and emotional engagement) as student factors influencing academic performance and attitude towards biology in a garden-based learning environment.

The following research instruments were utilized: Garden-based Learning Manual, Life Science Achievement Test (LSAT), Attitude Towards Biology Scale (ATBS), Learning Engagement Survey Questionnaire (LESQ), Students' Perception Towards GBL, and Reflection Journals. All instruments were researcher-made and expert-validated except for ATBS which was adopted from Fetalvero (2016). These three self-report survey questionnaires together with the achievement test were all administered at the end of eight-week period of the implementation of intervention. Qualitative analysis was conducted through focus group interviews, attitude questionnaires, activity reports, reflection journals, and in-depth probing interviews to gain a deeper understanding of students' perceptions of garden-based learning. Data obtained were analyzed using descriptive statistics. Measures of central tendency such as mean, frequencies and percentages were computed. The scores on Life Science Achievement Test obtained by the student were used in analyzing their level of academic achievement by comparing it to the DepEd standards. This study also employed Cramer's V and Kendall's Tau rank correlation coefficient. The Cramer's V was used to determine the degree of association between the extent of engagement in garden-based learning and profile variables while Kendall's Tau rank correlation coefficient was computed to measure the strength and direction of the relationship between extent of learning engagement, academic performance and attitude towards biology.

Summary of Key Findings

The summary of findings of the study presented below vis-à-vis the research problems asked:

As to the profile of the student-respondents, it appears that majority of the respondents were 17 years old (54.29%), followed by 16 years old (35.71%), and a small fraction being 18 years old (10%). In terms of sex, however, the participants were almost equally distributed between male (51.43%) and female (48.57%).

For the extent of engagement of students in Garden-Based learning, the overall results of the study revealed that students exhibit a high level of engagement in garden-based learning across all dimensions measured - cognitive, behavioral, and emotional. The overall mean of 3.21 suggests that garden-based approach is effective in engaging students deeply in their learning process. Behavioral engagement attained the highest mean of 3.29, which is interpreted as having a very high extent level of engagement followed by cognitive which has a mean of 3.23. Meanwhile, emotional engagement got the least overall mean of 3.10, indicating high level of emotional engagement in Garden-Based learning of student-respondents.

Based on the scores obtained from the Life Science Achievement Test (LSAT), the majority of students (65.71%) fall within the range of Average Mastery, indicating a basic level of understanding and skill in this subject area. A percentage of students (27.14%) are Moving Towards Mastery, showing a developing understanding and capability in Life Science. However, only a small proportion of students (4.28%) demonstrate a level of understanding Closely Approximating Mastery. No students fell into the categories of Mastered, Very Low Mastery, or Absolutely No Mastery. The overall mean score of 59.34 further reinforces that the average level of performance among students is at the level of Average Mastery. These results suggest that while students are engaged in the garden-based learning program, their level of mastery in Life Science is yet to reach the highest levels.

Students displayed a positive attitude towards the importance of Biology in their personal lives, with an overall mean of 3.36. Notably, they highly valued Biology as an essential part of their lives, acknowledging the advancements in Biology aimed at improving the quality of human lives and its potential to address various environmental issues. The students also agreed that they learn important concepts in Biology classes and find studying biological processes interesting.

With regards to the interest in Biology Lessons, the data suggests that students exhibit a strong interest in their Biology lessons, with an overall computed mean of 3.45 indicating their disagreement to negative statements about the subject. Students also demonstrated a generally positive perception towards their Biology teacher, reflected by an overall mean of 3.31. This positive perception seems largely influenced by the teacher's preparation for lessons, their approachability, and their commitment to student support.

Furthermore, data suggests a positive outlook on the students' attitudes towards Biology, particularly in terms of their keenness to learn the subject. Their attitudes are reflected by an overall mean of 3.19, suggesting that the students are not only diligently studying and reviewing Biology lessons at home but also actively engaged and focused during class hours.

In terms of enjoyment of Biology, the results revealed that the garden-based learning approach is contributing positively to the students' enjoyment of Biology, as reflected by an overall mean of 3.11. Moreover, the students display little to no anxiety towards Biology, as evidenced by a computed overall mean of 3.25. Finally, data presented also indicates that students have a strong inclination to put forth considerable effort in learning Biology with a computed overall mean of 3.39.

The result of the computed Cramer’s V showed that there is a low association students’ sex, and the extent of engagement in garden-based learning. Moreover, a weak association was observed between students’ age and extent of engagement.

There is a very weak negative monotonic association between cognitive engagement and academic performance as revealed by the negative Kendall’s tau-b value of -0.024. Likewise, a very weak negative monotonic association between behavioral engagement and academic performance as indicated by the negative Kendall’s tau-b value of -0.013. On the other hand, a Kendall's tau-b value of 0.001 for the association between academic performance and emotional engagement revealed that there is an almost negligible correlation between these two variables.

There is a weak positive monotonic association between the cognitive, behavioral and emotional engagement and attitude towards Biology as revealed by the positive Kendall’s tau-b values.

With regard to how students perceived their learning experience with Garden-Based Learning strategy, student-respondents reported several positive impacts of garden-based learning, a mean of 3.32 indicates that students strongly agreed that the approach had generally affected positively their learning process. Individually, the students strongly felt that GBL developed or enhanced their skills on critical thinking, interpersonal, self-efficacy, retention and recall, and the like. Most notably, students perceived GBL as an approach that helped them developed a pro-environmental behaviour and/or attitude and physical mobility of students, which may influence their overall mental health and wellness.

Conclusions

Based on the empirical data collected and subsequent analysis, this study presents the following conclusions:

As a science teaching strategy, garden-based learning may be adapted to many age groups, particularly in the middle to late adolescent years, and is equally engaging for students of both sexes.

Students exhibit a high level of learning engagement in garden-based learning across all domains of learning engagement- cognitive, behavioral and emotional. In particular, GBL approach can result to high level of behavioral engagement among students.

GBL is an effective instructional approach in improving students' academic performance in life science. Although students' test performance remains considerably lower than DepEd learning competency standards, there are pieces of evidence supporting it is as a comparable and feasible alternative approach that nurtures students' critical skills and can be added to science teachers' repertoire of pedagogical approaches.

Students displayed an overall positive attitude towards Biology. In particular, GBL is an effective science pedagogical approach in teaching students the importance of biology, fostering strong interest in learning Biology lessons, cultivating positive perceptions of their biology teacher, improving their eagerness to learn the subject, enhancing their enjoyment of Biology, mitigating anxiety towards Biology and encouraging them to put forth effort in learning biology.

There is a low association between the students' sex and their extent of engagement in garden-based learning and weak monotonic association between students' age and extent of engagement.

Academic performance of the students was discovered to have a very weak monotonic association towards the extent of learning engagement in garden-based learning. On the other hand, Cognitive, Behavioral and Emotional Engagements have weak positive monotonic association towards the students' attitude towards Biology.

Students perceived GBL improves their academic performance, learning engagement, appreciation and self-efficacy in science, retention and recall of learned scientific information, and increased curiosity for Biology concepts. In addition, GBL also develop students' interpersonal skills, self-discipline, self-worth, problem solving skills, exploration and cooperation and/or collaboration skills.

Recommendations

Considering the discussions and findings presented in this study, the following recommendations can be compiled:

For Science Education Supervisors/Specialists: This study underlines the effectiveness of garden-based learning strategy in improving students' engagement and performance in Biology. As such, it's recommended that science education supervisors/specialists advocate for the adoption of garden-based learning approaches and provide necessary resources and support for its implementation.

For Curriculum Designers and Developers: Given the demonstrated benefits of garden-based learning, curriculum designers and developers should consider incorporating this method into the broader Biology curriculum. Additionally, the curriculum should be designed to allow for personalization of learning experiences, catering to individual students' strengths and requirements.

For Science Teachers: It is recommended that science teachers receive specialized training on how to effectively implement garden-based learning into their teaching. Teachers should pay particular attention to nurturing emotional engagement, which has shown a correlation with academic performance and attitudes towards Biology. In addition, since gardens provide an excellent platform for integrating various subjects, such as science, math, language arts, and social studies among others, teachers are encouraged to design garden-based activities the incorporate interdisciplinary learning, enabling students to develop a holistic understanding of concepts.

For Learners: Students should be encouraged to engage fully with garden-based learning activities, appreciating that these learning methods can enhance understanding and performance in Biology, foster curiosity, and develop critical thinking skills.

Future Research Directions

Future research in the field of garden-based learning holds great potential for advancing our understanding of the educational, environmental, and social impacts of this approach. Here are some promising research directions:

Demographic Analysis. Aside from age and sex, future researchers may consider other profile variables of the respondents such as socioeconomic status, academic background, learning styles or preferences, personality traits, and ownership of land or home garden among others.

Longitudinal Studies. Conduct long-term studies to track the effects of garden-based learning on student engagement, academic performance and attitudes towards Biology. Investigate how early exposure to garden-based learning influences academic and career choices, environmental attitudes, and lifestyle.

Environmental Literacy. Assess the impact of garden-based learning on environmental literacy, including knowledge, attitudes, and behaviors related to environmental issues. Investigate how garden-based experiences influence a sense of stewardship and sustainable practices.

Comparative Experiments. Design comparative experiments that involve random assignment of students to groups with varying levels of exposure to garden-based learning. Compare outcomes, such as engagement, learning achievement, and environmental attitudes, between the control group (without garden-based learning) and the experimental group (with garden-based learning).

Parental Involvement and Student Achievement. Investigate the link between parental involvement in garden-based learning and student achievement.

Examine how different levels and types of parental engagement, such as involvement in garden activities or supporting garden-related homework, impact students' academic performance, motivation, and environmental attitudes.

Explore other Dimensions of Engagement. Researchers may explore additional dimensions of learning engagement that are relevant in the context of garden-based education such as such as social engagement, metacognition, self-regulation and academic resilience.

Quantitative Assessments of Engagement. Implement quantitative assessments of different dimensions of student engagement within garden-based learning, using probability sampling. Analyze the relationships between cognitive, emotional, behavioral, and social engagement and their impact on learning outcomes and attitudes toward biology.

Career Pathways within Science. Assess whether students' participation in garden-based activities is associated with a higher likelihood of choosing science-related courses and careers such as botany, ecology, horticulture, and conservation biology.

These research directions can contribute to a deeper understanding of the benefits and challenges of garden-based learning, inform best practices, and help promote its integration into formal and informal educational settings, as well as community programs.

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APPENDICES

Appendix A: Letter of Permit to the Schools Division Superintendent

November 16, 2020

HON. ROGELIO F. OPULECIA
OIC- Schools Division Superintendent
City Schools Division of Tanauan
J.P. Laurel Highway, Tanauan City, Batangas

Sir:

Greetings of Peace and Prosperity!

I would like to request permission to allow me to conduct my study entitled, ***"Engagement and Its Dimensions as Student Factors of Academic Performance and Attitude Towards Biology in a Garden-Based Learning"*** at Pantay Integrated High School, Pantay Matanda, Tanauan City, Batangas. This is in partial fulfillment of the requirements for the degree in Doctor of Philosophy in Education major in Biology Education at the University of the Philippines-Open University which I am currently enrolled.

The main purpose of my study is to use home garden as a platform in learning science and evaluate the relationship of the extent of engagement of the respondents toward garden-based learning to their academic performance and attitude towards Biology. The target respondents of this research are all Grade-11 students currently enrolled in Earth and Life Science subject.

Rest assured that all ethical measures will be observed in the course of data gathering and other research activities. Attached herewith is the summary of my proposal for your perusal.

May this request merit your approval. More power and may God bless you indeed!

Respectfully yours,

BAYANI T. VICENCIO
Researcher

APPROVED:

ROGELIO F. OPULENCIA
OIC- Schools Division Superintendent

Appendix B: Letter of Permit to Conduct Study to the Principal

December 14, 2020

MRS. PURIFICACION L. AGQUIZ
Principal I
Pantay Integrated High School
Pantay Matanda, Tanauan City, Batangas

Madam:

Greetings of Peace and Prosperity!

Attached is my request approved by the Schools Division Superintendent to implement the proposed instructional intervention, which is my dissertation entitled, ***"Engagement and Its Dimensions as Student Factors of Academic Performance and Attitude Towards Biology in a Garden-Based Learning"*** in our school. This is in partial fulfillment of the requirements for the degree in Doctor of Philosophy in Education major in Biology Education at the University of the Philippines-Open University which I am currently enrolled.

The main purpose of my study is to use home garden as a platform in learning science and evaluate the relationship of the extent of engagement of the respondents toward garden-based learning to their academic performance and attitude towards Biology. The target respondents of this research are all Grade-11 students currently enrolled in Earth and Life Science subject.

Rest assured that all ethical measures will be observed in the course of data gathering and other research activities. Attached herewith is the summary of my proposal for your perusal.

May this request merit your approval. More power and may God bless you indeed!

Respectfully yours,

BAYANI T. VICENCIO
Researcher

Appendix C: Profile of the Validators

I. Content Validator of Life Science Achievement Test (LSAT)

A. Validator 1: 36 years old; male; Education Program Supervisor in Science; with 13 years of experience in the field of science teaching and research; graduated PhD in Science Education from Philippine Normal University.

B. Validator 2: 63 years old; female; Master Teacher II (Science) specializing in chemistry; with 43 years of experience in the discipline; graduated Master of Education major in Chemistry Education from De La Salle University- Manila

C. Validator 3: 41 years old; female; Associate Professor specializing in Science Education; with 20 years of experience in the discipline; graduated PhD Educational Management from St. Jude College- Manila

II. Content Validator of Learning Engagement Questionnaire (LEQ)

A. Validator 1: 39 years old; female; Associate Professor IV with specialization in guidance and counseling, psychology and education management; with 17 years of experience in the field of psychology; graduated PhD in Guidance and Counseling from Philippine Normal University and PhD in Educational Management (CAR) from UPHSD.

B. Validator 2: 41 years old; female; Associate Professor specializing in Science Education; with 20 years of experience in the discipline; graduated PhD Educational Management from St. Jude College- Manila

C. Validator 3: 45 years old; male; Director of Graduate School and Director of the Office of Research, Evaluation and Publication in San Pablo Colleges; with 20 years of experience in the field; graduated PhD Educational Management from St. Jude College- Manila (Doc Lunar)

III. Attitude towards Garden-based Learning Questionnaire (ATGBLQ)

A. Validator 1: 52 years old; female; Assistant Professor at Institute of Biology, CAS, UP Diliman specializing in plant genetics, developmental biology and plant anatomy and morphology; graduated PhD Genetics from UPLB

B. Validator 2: 45 years old; male; Director of Graduate School and Director of the Office of Research, Evaluation and Publication in San Pablo Colleges; with 20 years of experience in the field; graduated PhD Educational Management from St. Jude College- Manila (Doc Lunar)

C. Validator 3: 48 years old; female; Assistant Professor at Lyceum of the Philippines University- Cavite specializing in Microbiology and Parasitology and Human Anatomy; graduated PhD in Science Education from University of the Philippines Open University

IV. Garden-based Manual

A. Validator 1: 52 years old; female; Assistant Professor at Institute of Biology, CAS, UP Diliman specializing in plant genetics, developmental biology and plant anatomy and morphology; graduated PhD Genetics from UPLB

B. Validator 2: 36 years old; male; Education Program Supervisor in Science; with 13 years of experience in the field of science teaching and research; graduated PhD in Science Education from Philippine Normal University.

C. Validator 3: 48 years old; female; Assistant Professor at Lyceum of the Philippines University- Cavite specializing in Microbiology and Parasitology and Human Anatomy; graduated PhD in Science Education from University of the Philippines Open University

Appendix D: Letter to the Validators of Garden-Based Learning Manual, Learning Engagement Survey Questionnaire (LESQ), Life Science Achievement Test (LSAT) and Questionnaire on Students' Perception Towards GBL

16 October 2020

Dear Content Validator,

Greetings of peace and prosperity!

I am BAYANI T. VICENCIO, a graduate student of University of the Philippines Open University taking up Doctor of Philosophy in Education major in Biology Education. I am currently doing my dissertation about Garden-based Learning and now on the process of validating my research instruments. One of the dependent variables of my study is student's achievement in the life science, a unit included in the Earth and Life Science core subject of senior high school. The target respondents who will be taking the test are the Grade 11 students both in academic and TVL tracks.

Your expertise will greatly help improve the instrument in order to yield valid and reliable results. Attached is the proposed Life Science Achievement Test (LSAT) for your perusal. Kindly inspect the questions and highlight those that are not clear and have some grammatical issues. After which, please check whether the questions are consistent with the topics indicated in the course syllabus.

I will greatly appreciate if you could e-mail me back your inputs on or before October 30, 2020. More power and may God bless you always.

Respectfully yours,

BAYANI T. VICENCIO

13 November 2020

DEAR VALIDATOR,

Greetings of Peace and Prosperity!

My name is BAYANI T. VICENCIO, a graduate student of the University of the Philippines-Open University (OPOU) in the program Doctor of Philosophy in Education major in Biology Education. I am currently on the stage of validating instruments for dissertation paper which is about Garden-Based Learning. May I humbly ask for your time to look into the appropriateness of the following instruments by accomplishing the attached validation form:

a. **Learning Engagement Questionnaire (LEQ)**
b. **Attitude towards Biology Scale (ATBS)**
c. **Life Science Achievement Test (LSAT)**
d. **Attitude towards Garden-based Learning Questionnaire (ATGBLQ)**

I will appreciate if you could accomplish the forms on or before November 30, 2020. Thank you so much for your time and effort. More power and may God bless you indeed!

Respectfully yours,

BAYANI T. VICENCIO

VALIDATION FORM
Part I. PROFILE OF VALIDATORS
Directions: Kindly fill up the information being asked.

1. Name

   ____

2. Sex

   ____

3. Age (in years as of last birthday)

   ____

4. Current Designation/Position

   ____

5. Institutional Affiliation

   ____

6. Address of the Institution

   ____

7. Numbers of Years of experience in the Field of Science/ Biology Education

   ____

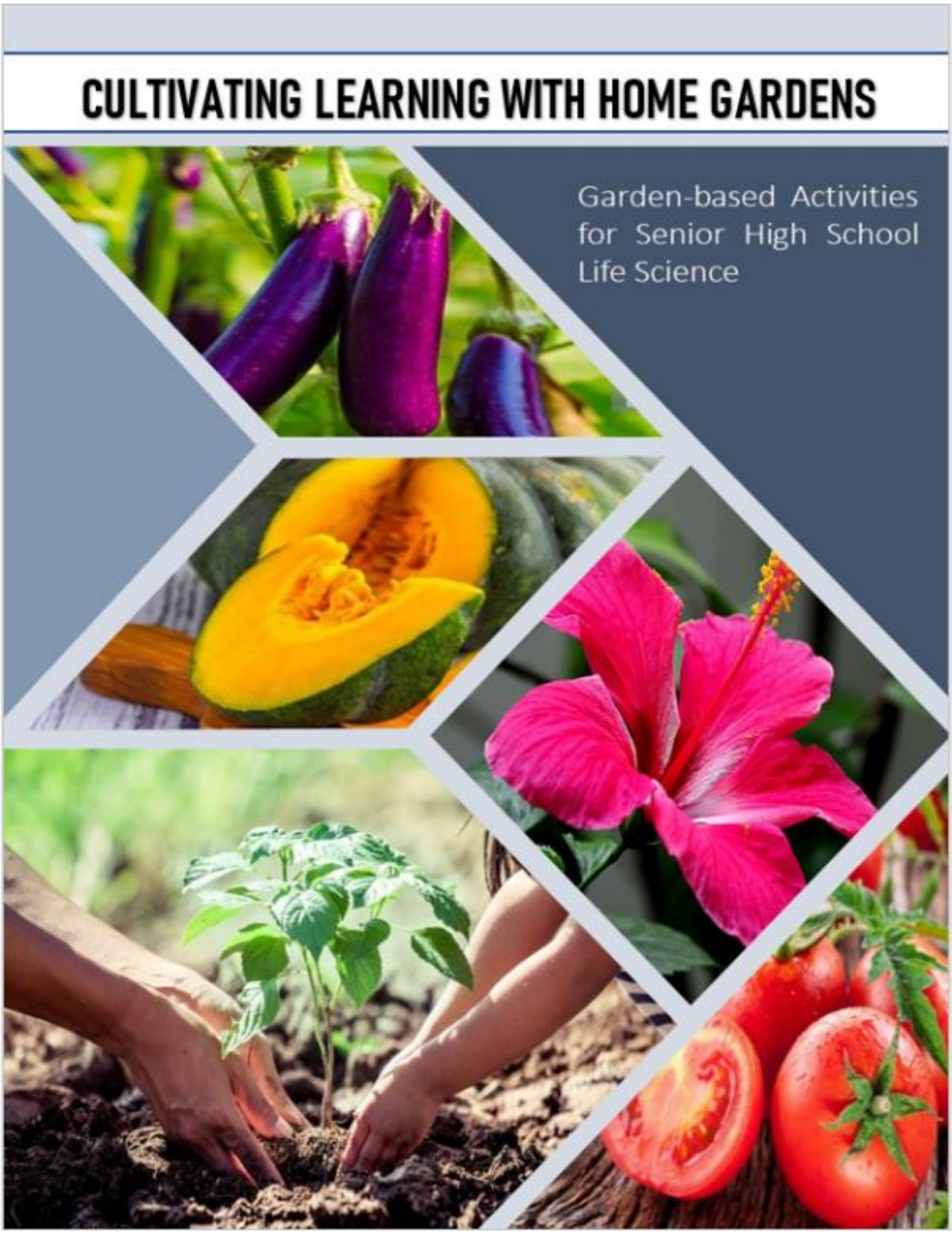
8. Specialization in PhD or EdD

   ____

9. Institution where PhD or EdD degree obtained

   ____

Appendix E: Validated Garden-Based Learning Manual



Activity 1: Crazy Little Thing Called Life

INTRODUCTION

Biology encompasses all studies that concerns life. But what is "life" exactly? How can we say that a thing is living or non-living(dead)? Biologists around the world agree that it is hard to give a one-line definition of life, however, it can easily be described using a particular set of vital processes common to all living things. As you go on this activity, you will learn the various characteristics common to all living things.

YOUR TASKS

1. Distinguish living from non-living things;
2. Describe how the unifying themes in the study of life show the connections among living and non-living things; and
3. Value life by taking care of all organisms in our environment.

THINGS NEEDED

Pen
Cellphone with camera
Video recorder (optional)

WHAT TO DO

1. Visit your home garden or any garden near your home and observe the things around it.
2. Name at least 10 things/organisms you see and write it in the first column of the table below. (You may also take photos of your samples using your cellphone as part of your documentation).
3. Classify them further by completing the remaining columns using the **MRS GREN** criteria of classification. Put a check mark (/) to the column that corresponds to the characteristic of living things exhibited by your samples.
4. Based from your answers, decide whether the object/organism is living or non-living.

DATA AND RESULTS

	M	R	S	G	R	E	N	Living	Non-Living
1.									
2.									
3.									
4.									
5.									
6.									
7.									
8.									
9.									
10.									

Legend: **M**- movement; **R**- respiration; **S**- sensitivity; **G**-growth; **R**-reproduction; **E**- excretion; **N**- nutrition

GUIDE QUESTIONS

1. What are the living things you have identified from this activity? How about the non-living things?

2. Which characteristics are found only in living things? found both in living and nonliving?

3. How do the living things you have identified obtain their nutrition? respond to their environment?

APPLICATION

1. How can farmers/gardeners use their background/knowledge on the characteristics of living things in taking care of their plants?

2. How does irritability contribute to chances of survival?

3. Would you consider novel corona viruses living or non-living? Justify your answer.

4. Most plants are stationary (fixed in one location). Does it affect their ability to reproduce and obtain their food?

CONCLUSION

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Quilal-lan, R.M., Aguinaldo, J.R., Dumlao, R.C., Acosta, E.B., Salud, N.J., Lucas, R.C., Caoibes, E and Guavez, L. (2003). Laboratory Manual for Science and Technology 2 (Biology). Eferza Academic Publications. Bagong Pook, Lipa City

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"The love for all living creatures is the most notable attribute of man"
- *Charles Darwin*

Activity 2: Investigating Plant Cell

INTRODUCTION

According to the cell theory, all living things are made up of cell be it plants, animals, protists, monerans or fungi. It is the basic structural and functional unit of life. Though plant cells are very small, it has a complex internal structure containing many smaller organelles. Each organelle has its own specific function to perform within the cell to carry on life processes and keep it alive. Some of these organelles can be easily seen using the compound microscope while other can be viewed only using the electron microscope.

YOUR TASKS

In this activity, you should be able to:

1. Prepare a wet mount using thin upper surface of the leaf and thin inner surface of onion scale;
2. Identify the observable parts of plant cell under the compound microscope; and
3. Draw plant cells as seen through the light microscope

THINGS NEEDED

compound microscope	razor blade	forceps	sharpened pencil
Glass slides	cover slip	iodine solution	medicine dropper

Specimens: onion bulb, leaf sample from the available plant in your home garden (e.g. petchay leaf, bangka-bangkaan leaf, gumamela leaf etc.)

WHAT TO DO

A. Leaf Sample obtained from the plant in the Home Garden

1. Go to your home garden and obtain one leaf sample from any available plant in your garden.
2. Using a sharp razor blade, peel off a thin layer from the upper surface of a leaf. (***CAUTION:*** Be careful of using the scalpel or blade!)
3. Place the thin section of the leaf on a glass slide. Add a drop of water on the leaf.
4. Examine the leaf specimen under LPO. Draw the cell as seen under LPO.

B. Onion Skin

1. Using a sharp razor blade, carefully peel off a thin layer of skin from onion. (**CAUTION:** Be careful in using the scalpel or blade!).
2. Using the forceps, place the thin section of onion skin on a glass slide. Make sure that the onion skin is not folded or wrinkled.
3. Examine the onion skin under the low power objective (LPO). Add one drop of water into the specimen and place a cover slip on top of the onion skin using the sharpened end of a pencil.
4. Remove the slide from the stage. Using a dropper, place one or two drops of iodine solution along the edge of the cover slip. Place a piece of tissue paper on the other edge of the cover slip. The tissue paper will absorb the water, and the iodine solution spreads out under the cover slip until the whole specimen is covered with stain.
5. Examine the stained onion cells under the LPO.
6. Draw the four to six cells as seen under LPO. Label the parts you have identified.

DATA AND RESULTS

leaf cells of _______________ under LPO

Onion skin cells under LPO

GUIDE QUESTIONS

1. Describe the cell of your leaf sample and onion skin cell as seen under LPO. What about onion cell? Differentiate the two cells in terms of shape and size. Is there similarity? What are the differences if there are any?

2. What are the parts of the plant cells you identified to both onion and leaf cells? What is/are the function/s of each part?

3. Did you observe any change in the image of the onion cells before and after adding iodine solution? How did the iodine solution affect the image of the onion cells?

4. Try to break your leaf sample? Is it easily breakable? What about the slice of onion? What part of the cell is responsible for maintaining its rigidity and strength?

APPLICATION

1. Your family had an out of town vacation for one week. When you arrived home, your mom hurriedly checked your plants and discovered that most of them are already wilted. Briefly discuss what happens to the cell of the plant and explain why this phenomenon occurs.

CONCLUSION

REFERENCES:

Gatapia, M.S.J., and Bernardo, Ma.E. V. (2001). Laboratory Activities (Text-Workbook) in Science and Technology II (Biology) Revised Edition. Innovative Educational Materials, Inc., Sta. Ana Manila.

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"The body is a cell state in which every cell is a citizen. Disease is merely the conflict of the citizens of the state brought about by the action of external forces."

— *Rudolf Virchow, from Die Cellularpathologie (1858)*

Activity 3: You LIGHT Up My LEAF

INTRODUCTION

Photosynthesis is often regarded as the most important life process on Earth. Cells of the autotrophs have photosynthetic pigments that are capable of trapping energy from the sun and convert it to chemical energy stored as sugar. Sugars produced and manufactures during this process are stored in the leaves and other parts of the plant in the form of starch.

In this activity, you will discover if photosynthesis has taken place in the leaves of the plant by determining if starch is present through iodine test.

YOUR TASKS

At the end of this activity, you should be able to:

1. Observe the effect of sunlight on the ability of the green plants to produce sugar molecules during photosynthesis.
2. Perform an iodine test to determine the presence of starch on leaves of green plants.
3. Show concern for plants by properly taking care of them.
4. Value life by taking care of all organisms in our environment.

THINGS NEEDED

Potted *Coleus* (mayana) plant	Scissors	Aluminum casserole
Aluminum foil	gas stove	Iodine solution
2 petri dishes/saucers	2 (150-ml) beaker	

WHAT TO DO

1. Cut three strips of aluminum foil long enough to entirely cover both the upper and lower surface of a mayana leaf. Draw and cut letter M, Y, and N on each of the aluminum foil strips near one end. Select three leaves and cover it with aluminum foil on it. Use paper clips to fasten it in place. The number of leaves covered will serve as the number of replicates.
2. Expose the potted mayana (*Coleus blumei*) plants to sunlight for two (2) days.
   Note: This should be done two days prior to the actual activity. Also, sunlight can dry up the leaves so water the plants well.
3. After two days, cut off the covered leaves from the plant and remove the aluminum foil.
4. Put the three mayana leaves in a beaker containing 15 ml of 70% ethyl alcohol (or acetone) and soak for few minutes until the color of the leaves become lighter. You may put the beaker containing the leaf samples for 45-60 minutes on a hot water bath (boiled water on an aluminum casserole). Constantly change the beaker with leaf sample with fresh alcohol every time the alcohol turns green.
   Caution: Alcohol/acetone is highly flammable so it must be heated indirectly. Do not allow an open flame near the alcohol as it may explode.
5. Carefully remove the leaves from the beaker using forceps. Rinse the leaves in water then place in separate petri dishes/saucers. Label each as Replicate 1, Replicate 2 and Replicate 3.
6. Put 10-15 drops of iodine solution on each leaf sample and leave it for 5 minutes. Observe for color reaction. Rinse the leaves with water and observe again.

DATA AND RESULTS

Directions: Draw and label the appearance of the leaves in each replicates in response to the iodine test for the presence of starch in leaves you have conducted.

Replicate 1	Replicate 2	Replicate 3

GUIDE QUESTIONS

1. Describe the appearance of the covered portion of the green leaves when the whole plant was exposed to the sun? What can you infer from this observation?

____
____
____
____
____

2. What is the purpose of soaking and/or boiling the leaves in 70% ethyl alcohol or acetone for 20 minutes?

____
____
____
____
____

3. What happens to the color of the alcohol mixture several minutes after the leaves were dropped? What is present in the mixture that makes it colored?

____
____
____
____
____

4. Based on the color reaction of each saucer, in which leaf is starch present?

5. After the iodine test, what happened to the uncovered and covered areas of the leaf?

6. Compare the appearance of green and white areas of mayana leaf? Which area had blue color? Why?

APPLICATION

Photosynthesis is affected by several factors including intensity and color of light. How can this idea help farmers enhance their crop production?

CONCLUSION

REFERENCES:

Department of Education. (2017). Science 7 Learner's Material. Department of Education-Bureau of Learning Resources (DepEd-BLR). Meralco, Ave., Pasig City.

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"I thought I was pretty cool until I realized that plants can eat the sun and poop out air."

- Jim Bugg

Activity 4: Evidence of Photosynthesis

INTRODUCTION

Photosynthesis is often regarded as the most important life process on Earth. Cells of the autotrophs have photosynthetic pigments that are capable of trapping energy from the sun and convert it to chemical energy stored as sugar. The sugar produced and manufactured during this process are stored in the leaves and other parts of the plant in the form of starch.

In this activity, we will demonstrate that leaves release gas in the presence of light and carbon dioxide. While we cannot prove in this activity that the bubbles are oxygen without using a gas probe, we can still demonstrate that bubbles are formed when the leaves are submerged in sodium bicarbonate (which releases CO_2) and not when they are submerged in pure water.

YOUR TASKS

At the end of this activity, you should be able to:

1. Demonstrate that in the presence of light, water, and carbon dioxide, leaf tissues produce gas bubbles; and
2. Appreciate the important role played by plants in the environment especially in the exchange of gases.

THINGS NEEDED

Fresh leaves from plant in your home garden (e.g. gumamela, fortune plant, bougainvillea, pechay, cassava, kangkong etc.)
Puncher
10 ml syringe without needle
Baking soda solution (pinch of baking soda dissolved in 30 ml
Liquid dish soap solution (5ml liquid soap dissolved in 50 ml water)
3 plastic cups, each contains the following:

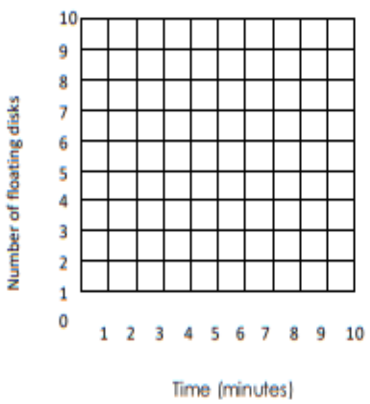
Cup 1: Liquid detergent solution
Cup 2: Baking soda solution (treatment)
Cup 3: Water (control)

Light source (LED Light)- LED light is a good because it produces light without much heat

WHAT TO DO

1. Choose a plant in your home garden and gently remove 2-3 leaves.
2. Using a puncher, cut 20 leaf disks from the leaf. Ten (10) leaf disks will be used for control set-up while the remaining 10 will be used for the treatment set-up.
3. Get a 10 ml syringe and separate its plunger from its body. Drop 10 of the leaf disks inside then reassemble the syringe.
4. Push the plunger almost to the bottom but avoid crushing the disks.
5. Get another syringe and repeat steps 3 and 4. The first prepared syringe will serve as the control, while the second syringe will be treatment.
6. Using the syringe in the **control set-up**, draw up 2 mL of detergent solution, and then draw 3ml **water** until the mixture reaches up to 5 mL. On the other hand, using the syringe for the **treatment** set-up, draw up 2 mL of detergent solution, and then draw the 3 ml **baking soda solution** until the mixture reaches up to 5ml mark.
7. For both set-up, point the syringe upward, tapping the sides, so that any air bubbles rise, and gently squeeze the syringe until liquid begins to come out.
8. Put a finger on the end of the syringe, and draw the plunger back slightly, creating a partial vacuum.
9. Repeat until the leaf disks are suspended in the solution. This action forces the liquid into the interior of the leaf.
10. You may watch this video of the process to make sure you're doing it right. Link: (https://youtu.be/vw8baZO89oc)
11. Pour the contents of control and treatment syringes into two labelled clear plastic cups, control and treatment set-up respectively.
12. Swirl the liquid to try to keep the disks from sticking to each other or onto the sides of the cups and then let them sit for 5 minutes.
13. Turn on a bright light and monitor the disks every minute. Count how many disks are floating during each of the next 15 minutes.
14. After all (or most) of the disks are floating, put the cups in the dark (a shoebox or a closet) and monitor for the next 15 minutes.
15. Record how many disks remain floating after each minute until all (or most) of them have sunk.

DATA AND RESULTS



Guide Questions:

1. What is the purpose of the baking soda solution in the treatment set-up?

2. Describe what will happen when both the control and treatment set-up was exposed to the light source.

3. Why do the leaf disks in the baking soda solution (treatment) begin to float?

4. Why do the leaves begin to sink again when the set-up was placed in the dark?

5. Why don't the leaves in the baking soda solution continue to produce oxygen in the dark?

APPLICATION

Aside from aesthetic purposes, plants play an important ecological role since they give off oxygen needed both by plants and animals to breathe. Do you think it is necessary to have indoor plants inside your room during nighttime? Explain your answer.

CONCLUSION

REFERENCES:

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"We must learn to think not only logically but BIO-logically"
- *Edward Abbey*, In One Life at a Time, Please (1988)

Activity 5: From Seeds to Seedlings

INTRODUCTION

Just like animals, plants go through different stages of development. In most cases, plant development starts right after fertilization occurs. For example, in the bean plant, the embryo or tiny plant reaches a complex stage of development within the seed. When the seed matures, the embryo stops developing and remains dormant until favorable conditions allow them to grow. The first structure to appear when the seed germinates is the embryonic root followed by the stem with one or two green cotyledons. Each cotyledon contains food and nutrients for the developing seedling.

YOUR TASKS

At the end of the activity, you should be able to:

1. Examine the parts of a seed and their function.
2. Observe what happens to a seed when it germinates; and
3. Distinguish monocot from dicot plants based on their seed type.

THINGS NEEDED

mungbeans, soaked in water overnight
corn seeds, soaked overnight

petri dish	dilute iodine solution
hand lens	Razor blade
medicine dropper	paper towel or white cotton cloth

WHAT TO DO

Part I: What's In a Seed: Observing Plant Embryos

1. Using a hand lens, closely observe the external features of the mungbean and corn seed. Draw both seeds and identify the following structures: the seed coat, hilum, cotyledon, embryo, epicotyl and hypocotyl.
2. Remove the seed coat of the soaked mungbean seeds and separate the cotyledons.
3. Now, remove the embryo from the cotyledons and place it on moist paper towel or cotton cloth in a petri dish.
4. Look at the embryo with a hand lens. Draw the embryo.
5. This time put a corn seed on a piece of paper towel or white cloth in a petri dish.
6. Cut the corn seed vertically into two halves.
7. Put a drop of iodine solution on the cut surfaces. The part that does not turn blue, blue black or violet does not contain starch.

Part II: Studying Plant Growth and Development

1. Spread a paper towel/newspaper on a flat surface and moisten it with water until it is thoroughly damp. Do not dampen to point of runoff or dripping.
2. Arrange eight to ten soaked bean seeds in a row along one edge of a piece of paper towel/news paper. Do the same procedure for the corn seeds.
3. Moisten another paper towel/ newspaper and carefully place onto the first paper towel/newspaper, leaving the seeds sandwiched between the two sheets of paper towels/newspapers.
4. Roll up the two towels with the seeds in-between and place in a Ziplock plastic bag and place it in a room temperature. *Note: Avoid exposing the bag containing seeds from direct sunlight.*
5. Mark the Ziplock with the date and variety of seed it contains.
6. After the required germination period (mungbean- three days; corn- five days), remove the towels from the Ziplock bag and unwrap the seeds carefully so that the fragile shoots are not destroyed.
7. Examine the roots and shoot of the seedling. Draw and label its parts.

DATA AND RESULTS

Directions: Draw and label the parts of:

A. Corn Seed B. Corn Seedling	A. Mungbean Seed B. Mungbean Seedling

GUIDE QUESTIONS

1. What plant parts did you observe in the bean embryo? In corn embryo?

2. How can you distinguish if a seed is a monocot or a dicot? Is a bean seed a dicot or a monocot? How about the corn seed?

3. Based from your observation, what part of the developing seed was established first?

4. What part of the embryo gives rise to the root of a bean plant? How about the part of the embryo that produces the first leaves?

5. Where are the first leaves of the seedling located? Which part or parts of the embryo developed into the stem? How are the first two tiny leaves arranged on the stem?

APPLICATION

What is parthenocarpy? How does this process or phenomenon occur in the reproduction of bananas and pineapples, both of which have no seeds?

CONCLUSION

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"The tiny seed knew that in order to grow, it needed to be dropped in dirt, covered in darkness, struggle to reach the light."

- *Sandra King*

Activity 6: Propagating Plants through Stem Cuttings

INTRODUCTION

In horticulture, stem-cuttings are the most commonly used method of vegetative (asexual) propagation technique, suited well to herbs and ornamental plants. It involves taking a portion of a stem from a parent plant which is capable of rooting, thus used to grow into a whole new plant. Since the reproduction is asexual, the new plant is genetically identical to the parent and is often referred to as a clone.

YOUR TASKS

At the end of the activity, you should be able to:

1. Propagate plants through stem cuttings.
2. Repurpose empty PET/soda bottles into vertical garden pots.
3. Show concern to the environment by performing simple recycling activity.

THINGS NEEDED

stem cuttings of moss rose or portula	soil mixture	cutter
sharp pair of scissors	Nylon thread	stick
1.5 soda bottles, empty and clean	soldering iron	

WHAT TO DO

A. Preparing the Stem Cuttings

1. Using a pruning scissors or ordinary scissors, cut several stem cuttings (about 2-5 inches) of moss rose /portula off from the mother plant.
2. Remove the bottom leaves of the cutting that may come contact with the potting soil. Remove also the flower buds from the stem.

Note: *The top leaves will provide the energy needed to grow new roots while removing flower buds on the cuttings will make it efficient in using the energy in producing new roots rather than flowers.*

B. Preparing the self-watering soda bottle planters

1. Obtain several empty soda bottles. Remove the label, clean and thoroughly rinse the bottle.
2. Poke holes approximately one inch apart at the top of the bottle.
3. Using a sharp cutter or sharp pair of scissors, cut the soda bottle into half.
4. Remove the cap from the bottle. Using scissors, carefully create a hole large enough for the yarn or wicking fabric to pass through in the center of the cap. To make a wicking fabric by cutting several strips of fabric from old clothes approximately 4 inches long and 1 inch wide.
5. Insert two wicking fabric into the bottle cap and tie a knot at one end. Twit the cap back into the bottle.
6. Fill the bottom of the bottle about half full of water and invert the top of the bottle into the bottom of the bottle.
7. Add soil to the top of the bottle.

C. Planting the Stem Cuttings

1. Using a stick, make a 2-inch deep hole in the potting soil.
2. Push the cutting about 1.5 to 2 inches deep into the soil. Then gently press down onto the soil to compact it.
3. Make sure that the stem cuttings do not remain loose.
4. After planting, water the cuttings thoroughly. Place a plastic bag over the soda bottles with cuttings to decrease transpiration or water less from the cuttings
5. Place the plant in an area where it will receive enough sunlight

DATA AND RESULTS

Directions: Take a photo of your planted stem cuttings. From day 0, day 5, day 10 and day 20.

GUIDE QUESTIONS

1. What form of asexual reproduction did you perform in this activity? Name other forms of asexual reproduction undergone by plants?

2. How will you describe the genetic composition of the stem cuttings of portula and the mother plant from which it was derived?

3. What are some benefits to asexual propagation? What are some potential problems with asexual propagation?

4. Can you give other plant species, that can be propagated through stem cuttings?

APPLICATION

What is genetic engineering? What are some applications of genetic engineering in the field of agriculture?

CONCLUSION

"**Watching something grow is good for morale. It helps us believe in life**".

-Myron S. Kaufman

Activity 7: Leaf Morphology

INTRODUCTION

Leaves are the primary food producing organs of a plant. They are designed to be efficient in collecting light and using that light energy to produce food.

In this activity, you will realize that leaves vary in shape, size, color, arrangement of veins, type of attachment to stem and texture. And these variations reflect their evolutionary origin and enable them to adapt and survive to diverse kind of habitat.

YOUR TASKS

At the end of the activity, you should be able to:

1. Describe the gross morphological structure of a leaf;
2. Classify leaves based on morphology;
3. Value the diversity of plants in terms of their leaf morphology.

THINGS NEEDED

Various plants available in the home garden
Sheets of newspaper
Paper tape
Pentel pen

WHAT TO DO

1. Go to your home garden and obtain at least 10 different leaf samples from the plants that can you find there. Try to find a plant that is unique to your class so you can compare your results with other members of your class.
2. Place your collected leaf samples in newspaper fold and label them as Sample 1, Sample 2 and so on using a paper tape and pentel pen.
3. Examine each leaf samples you have collected and record your data on the Data and Results part of this activity sheet. Use the attached Illustrated Leaf Morphology as your guide in answering the questions below. In addition, classify your samples as a monocot or a dicot leaf.
4. Once you are done with the examination and recording your data, place again the leaf samples to their respective newspaper fold and place in between pages of a book to dry. You may mount each leaf sample on a short bond paper using glue and submit to your teacher together with the accomplished activity sheet.

DATA AND RESULTS

A. Local Name of Plant	
B. Leaf Morphology	
B.1. Type	
B.2. Shape	
B.3. Margin	
B.4. Tip	
B.5. Base	
B.6. Venation	
B.7. Arrangement	
D. Classification	

A. Local Name of Plant	
B. Leaf Morphology	
B.1. Type	
B.2. Shape	
B.3. Margin	
B.4. Tip	
B.5. Base	
B.6. Venation	
B.7. Arrangement	
D. Classification	

A. Local Name of Plant	
B. Leaf Morphology	
B.1. Type	
B.2. Shape	
B.3. Margin	
B.4. Tip	
B.5. Base	
B.6. Venation	
B.7. Arrangement	
D. Classification	

A. Local Name of Plant	
B. Leaf Morphology	
B.1. Type	
B.2. Shape	
B.3. Margin	
B.4. Tip	
B.5. Base	
B.6. Venation	
B.7. Arrangement	
D. Classification	

A. Local Name of Plant	
B. Leaf Morphology	
B.1. Type	
B.2. Shape	
B.3. Margin	
B.4. Tip	
B.5. Base	
B.6. Venation	
B.7. Arrangement	
D. Classification	

A. Local Name of Plant	
B. Leaf Morphology	
B.1. Type	
B.2. Shape	
B.3. Margin	
B.4. Tip	
B.5. Base	
B.6. Venation	
B.7. Arrangement	
D. Classification	

A. Local Name of Plant	
B. Leaf Morphology	
B.1. Type	
B.2. Shape	
B.3. Margin	
B.4. Tip	
B.5. Base	
B.6. Venation	
B.7. Arrangement	
D. Classification	

A. Local Name of Plant	
B. Leaf Morphology	
B.1. Type	
B.2. Shape	
B.3. Margin	
B.4. Tip	
B.5. Base	
B.6. Venation	
B.7. Arrangement	
D. Classification	

GUIDE QUESTIONS

1. What is the most common leaf shape, leaf margin, and phyllotaxy (leaf arrangement) identified by your group?

2. Let's say for example you are a taxonomist; how will you know if a plant is a monocot or a dicot by merely looking at its leaf venation? Using your leaf specimens, name the monocot and dicot plants identified by your group in this activity?

3. Do you think there is a connection between leaf morphology (e.g. size, shape, etc) and the adaptive mechanism of the plant to its environment? How?

APPLICATION

In cacti and some other desert plants, leaves have the form of spines and lack chlorophyll. How are these modifications of leaf structure related to the environment in which these plants grow?

CONCLUSION

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"Anyone can love a rose, but it takes a lot to love a leaf. It's ordinary to love the beautiful, but it's beautiful to love the ordinary".

- MJ Korvan


LEAF SHAPES
Lanceolate
Ovate
Obovate
Star-shaped
LEAF FORMS
Linear or Rectangular
Heart-shaped or Orbicular
Oval
Elliptical
Deltoid
LEAF APEXES (tips)
Acuminate
Acute
Obtuse
Truncate
Bristle Pointed
Rounded
LEAF MARGINS (edges)
Entire
Dentate
Toothed or Serrate
Sinuate or Wavy
Doubly Serrate
Lobed
Incised
LEAF BASES
Wedge-shaped or Cuneate
Inequilateral
Rounded
Heart-shaped or Cordate
Truncate
LEAF TYPES
BROADLEAVES
SIMPLE
COMPOUND
Leaflets
Compound leaf forms vary among many tree species.
NEEDLES
Needles or Acicular
Awl-shaped Needles
Scale-like Needles
PARTS OF A SIMPLE LEAF
Stem
Base
Petiole
Lamina or Blade
Primary Vein
Leaf Margin
Secondary or Lateral Veins
Apex
LEAF ARRANGEMENT
Opposite
Alternate
Fascicled (2–5 bundled needles)

Activity 8: Is it a monocot or a dicot?

INTRODUCTION

Botanists place all the flowering plants in the angiospermae class. They think of a flower as a short branch bearing groups of leaves. Some of these may resemble ordinary leaves. Others are so different in structure that it is hard of think of them as leaves at all.

In this activity, you will note the difference among the groups of flowering plants: the dicot and monocot.

YOUR TASKS

At the end of this activity, you should be able to:

1. Differentiate monocots from dicots based on their number of cotyledon(s), leaf venation, type of roots and floral parts.
2. Classify the given plant specimens into monocot or dicot.
3. Appreciate the importance of diversity of organisms.

THINGS NEEDED

Seeds of mongo, mustasa, string beans, corn (soaked for 2 days)
Actual specimens of flowers of: santan, cosmos, white angel plant, gumamela, and zinnia
Actual specimens of leaves of: santan, cosmos, white angel plant, gumamela and zinnia

WHAT TO DO

Part I. as to Number of Seed Leaf

1. Monocot seeds has one cotyledon while dicot has two seed leaves. Examine the germinated seeds of mongo, mustasa, string bean and corn particularly the number of cotyledon formed. Classify each specimen whether it is a mocot or dicot. Write your answers on the table below.

Part II. As to Floral Parts

1. If you count the number of petals, stamens, or other floral parts, you will find that monocot flowers tend to have a number of parts that is divisible by three, usually three or six. Dicot flowers on the other hand, tend to have parts in multiples of four or five (four, five, ten, etc.). Classify each of your flower specimen whether it is a monocot or dicot by examining the number of petals present.

Part III. As to Leaf Venation

1. Monocot leaves are characterized by their parallel venation while dicot leaves are characterized by branching or netted (i.e. pinnately or palmately) venation. Classify each of your leaf specimens whether it is a monocot or dicot.

DATA AND RESULTS

Table 1. Classification of seed based on the number of seed leaf

GERMINATED SEED SPECIMEN	NO. OF COTYLEDON (SEED LEAF)	CLASSIFICATION (monocot or dicot)

Table 2. Classification of plants based on number of floral parts and leaf venation

PLANT SPECIMEN	NO. OF PETALS (multiples of 3 or 4/5)	LEAF VENATION (parallel or netted)	CLASSIFICATION (monocot or dicot)

GUIDE QUESTIONS

1. Which of the seeds are monocot? dicot?

2. Which leaf specimens have netted veins? Have parallel veins?

3. Which plants are monocot? dicot?

4. Aside from number of cotyledon(s), leaf venation and number of floral parts, can you give other distinguishing characteristics that can be used in classifying monocot from dicot plants?

APPLICATION

Give examples of monocot and dicot plants that are beneficial and harmful to humans. Discuss in what way they are useful and harmful?

CONCLUSION

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"Your MIND is a GARDEN. Your THOUGHTS are the SEEDS. You can grow FLOWERS or you can grow WEEDS.".

- 2 Corinthians 10:5

Activity 9: Modified Roots, Stems and Leaves

INTRODUCTION

Based on morphology, plant body is divided into two main systems- the root system and the shoot system. The root system primarily involves the roots while the shoot system consists of the stem, leaves and flowers. Aside from their basic functions, these parts can also be modified or specialized to perform other tasks. Examples of specialized plant organs are the climbing roots, food storage roots and stems, tendrils in vines and leaves of carnivorous plants.

This activity will allow you to discover the various modifications in plant's roots, stems and leaves and their function.

YOUR TASKS

At the end of the activity, you should be able to:

1. Identify the modified roots, stems and leaves that can be found in garden plants.
2. Give the function of modified/specialized roots, stems and leaves; and
3. Recognize the importance of root, stem and leaf modification as adaptive structures of plants.

THINGS NEEDED

Possible Plant specimens:

Bougainvillea	Lemongrass (tanglad)	Carabao grass
Katakataka	Irish potatoes or sweet potato	Ampalaya/ Squash
Cactus	Ginger plant	Makahiya plant
Onion bulb	Carrot	
Bean plant	Gabi plant	

Magnifying lens
shovel
Reference book

WHAT TO DO

1. Proceed to your home garden and look for representative plants which possess modified or specialized plant parts such as roots, stems and leaves. Then accomplish the table below.

Note: *In identifying the modified roots, carefully dig the soil using shovel. Avoid as much as possible to damage the roots of the plant. For the stems and leaves, do not detach leaves on the stem. Use hand lends if necessary and/or take some photo for documentation for further investigation.*

DATA AND RESULTS

A. Modified /Specialized Roots

Representative Plant Sample found in in your Home Garden	Type of Specialized Root	Specialized Function
1.		
2.		
3.		
4.		
5.		

B. Modified/Specialized Stem

Representative Plant Sample found in your Home Garden	Type of Specialized Stem	Specialized Function
1.		
2.		
3.		
4.		
5.		

C. Modified/Specialized Leaves

Representative Plant Sample found in your Home Garden	Type of Specialized Leaves	Specialized Function
1.		
2.		
3.		
4.		
5.		

GUIDE QUESTIONS

1. Based from the activity, enumerate the specialized functions of roots aside from its primary function of absorption and anchorage? specialized function of leaves aside from photosynthesis? and specialized function of stem aside from transport and

2. Some of the plant structures are modified to perform specialized function particularly for survival and adaptation. Give some of the morphological adaptations possessed by most desert plants like cactus?

3. How are rhizomes, tubers and corms distinct from one another?

4. Aside from the abovementioned examples of modified leaves, there is also an insect-trapping leaf which is highly specialized for attracting, capturing and digesting insects. Give examples of the plant with insect trapping leaves.

APPLICATION

Which is more beneficial to plants- having a climbing stem or an erect stem? Explain your answer.

CONCLUSION

Activity 10: Grow a Garden in a SNAP!

INTRODUCTION

What do plants need to grow? Most of you would answer that they need light, air, water and soil. But would you believe that you can grow plants without soil?

As lands for growing crops become more scarce, people are looking for smarter and more efficient ways to grow foods. This gave birth to hydroponics, an innovative technique of growing plants solely in water.

YOUR TASKS

At the end of the activity, you should be able to:

1. Grow vegetable plants in school using hydroponic technology;
2. Recognize the importance of hydroponics technology in sustainable food production.

THINGS NEEDED

Seeds that can easily germinate (e.g. lettuce, basil, petchay etc.)
Growing medium (e.g. coconut coir, foam, or
Nutrient solutions (SNAP A and SNAP B obtained from UPLB)
7 pcs of empty 1.5 PET bottles
Styrofoam cups (8 oz)
Seedling tray Garbage bags (XL size)
Duct/masking tape
Tap water
Soldering iron

WHAT TO DO

A. **Preparation of Grow Box and Seedling Plugs**

A.1. Grow Box

1. Cut out holes on the lid of the Styrofoam box leaving equal space in between holes. Holes should be about 3 inches in diameter, numbering 5-8 per styrofoam fruit box.
   Tip: *You may use tin can as punchers to make perfect circles.*
2. Line the inside of the bottom of the Styrofoam box with the plastic sheet. Secure with duct tape. Patch up any small holes in the box with duct tape.

A.2 Seedling Plugs

1. Using a cutter, cut slits at the bottom and sides of the Styrofoam cups to give seedlings room to grow out their roots. Fill at least a quarter of the cup with coconut coir dust.
   Caution: *Avoid playing with the cutter to prevent from being wounded.*
   If untoward incident occur, notify your teacher immediately.

Page | 36

B. **Growing of Seedlings**

1. Fill a seedling tray with coconut coir dust. Scatter the seeds evenly across the seedling tray and cover again with coconut coir dust. Moisten a paper towel with water.
2. Water the seeds everyday and let them germinate for 1-2 weeks before transplanting.

C. Transplanting the Seedlings

1. Pour 10 liters of tap water into your grow box. Pour in 25 ml of SNAP solution A. Mix well. Then pour 25 ml of SNAP solution B. Again, mix well/ Cover the bottom portion of the Styrofoam box with its lid that now contains holes.
Note: It is important that you mix right after pouring in Snap solution A as the two solutions may react with each other if combined in undiluted forms.
2. Transfer the grown seedling carefully into your seedling plugs (Styrofoam cups with slits and coconut coir dust) making sure that they remain upright. Place these seedling plugs into the holes of the Styrofoam box lid.
3. Locate the grow box in an area where seedlings can get enough sunlight but be protected from the rain.

D. Taking Care of the Plants

1. Hydroponic plants are low-maintenance. No need for regular watering.
2. Replenish your solution every month. If your vegetables take more than a month to grow. Replenish to a level not higher than the bottoms of the seedling plugs/Styrofoam cups, not to its initial level as this might submerge and kill aerial roots.
3. Use the same proportion and process to prepare the mixture to be poured in: 10 liters of water 25ml SNAP Solution A: 25 ml SNAP solution B.
4. Observe the plant and write down your observations. Record the day (how many days the plant has been growing). Measure the plant height (above the seed basket) and root length. You can measure the roots by briefly pulling out the seed plugs and holding a ruler next to the roots. If possible, take photos of the plants and attach the pictures to your journal.

DATA AND RESULTS

Week & Day	Plant Height (cm)	Root Length (cm)	Observations

GUIDE QUESTIONS

1. Differentiate hydroponics from geoponics?

2. How do plants survive and sustain its life through hydroponics?

3. What are the nutrients present in SNAP solution?

4. Is hydroponic planting technique applicable to all types of vegetables? Why or why not?

APPLICATION

Cite the advantages and disadvantages of hydroponic technology.

CONCLUSION

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"Gardening requires lots of water, most of it in the form of perspiration".

- Lou Erickson

Activity 11: Make Your Own Herbarium

INTRODUCTION

Herbarium is a collection of plants, which are dried, pressed, mounted on herbarium sheets, identified and classified according to some approved system of classification for future reference and study. Just like a library, herbarium serves as a repository of information about various plant species that can be found in a specific area. Thus, it is an indispensable tool for most botanists and plant taxonomist around the world.

In this activity we are going to press and dry leaves and then make our own herbarium sheet!

YOUR TASKS

At the end of this activity, you should be able to:

1. Collect leaf specimens from the common plants in the home garden.
2. Identify the taxonomic classification of the collected leaf specimens; and
3. Prepare an herbarium of the identified plants in the garden.

THINGS NEEDED

During field collection: garden clippers or scissors
Ziplock or plastic bags
Paper tape to be used as identification tags
Marker pen
Field Notebook
Ballpen
Camera (optional)

For pressing the specimen: plant press or 2 cross-slatted bamboo frame
Sheets of newspaper
Corrugated board/carton
Straw
heavy books as weights

For mounting and labeling: Herbarium sheet or A4 bond paper (16.5 "x 11")
Glue
Herbarium label (4" x 3")

WHAT TO DO

A. Collecting the Specimen

1. Visit your home garden and choose at least five (5) different species of plant that you want to preserve and study in this activity.
2. Collect leaf specimens from each of your chosen plant that are in good condition, free of insect damage or disease. Collect your specimens in triplicate so that when you mount it, you can show both the upper (top) and lower (bottom) side of the leaf while the other one will serve as an extra.
3. Place the collected leaf samples from each plant species to separate Ziplock bag or plastic bag then put label tags and specimen number.
4. In your field notebook, record the following: date when the specimen was collected, collection number, location, habitat, habit and other special characteristics (like odor, color, etc). You can also take photos of the plant for future reference.

B. Pressing

1. Make sure that all your specimens are clean before pressing.
2. Place your plant between folded-out sheets of newspaper. Arrange the plant carefully, trying to avoid overlapping. If your specimen is large enough, you may fold it in "N" or "W" or "V" shape.
3. When you have finished arranging the specimens within the newspaper sheets, you then need to intersperse them between corrugated card sheets to aid ventilation.
4. To complete the plant press, stack several plant-newspaper-cardboard sandwiches together and place wooden boards or lattices on top and below (refer to the picture). Lattice is also preferred to boards as it also helps the specimens to dry faster.
5. Around the stack, wrap rope or nylon straps and while applying pressure, tie or fasten to hold the press together. If you do not have a plant press, pressure may be applied by piling telephone or heavy textbooks on top of the stack. Either way, the pressure should be even across the specimens so they dry flat.
6. Check your plant press regularly while drying to ensure that insect or fungal attack does not occur, and to reposition the leaf samples. Initially newspaper sheets should be replaced daily to remove moisture. After the third day this can be done every 2-3 days until the specimens are dry.

C. Preparation of Herbarium Label

1. Using the internet, research for the information related to your leaf sample such as: scientific name, local name, taxonomic classification, habitat, habit description and others (refer to the herbarium label shown below).
2. Once all the information have been accomplished, print it on a 3" x4" bond paper.

D. Mounting, Labeling and Filing/Storage of Herbarium Specimen

1. When your leaf sample is totally dried, remove it from the newspaper and carefully glue it on the herbarium sheet (16.5" x 11") in a portrait (vertical) orientation. In this case, you will have to glue the same leaf samples, one showing the front side of the leaf while the other is showing the back side of the leaf. Be creative in mounting your leaf sample.
2. Place the cut herbarium label on the bottom right-hand corner of the herbarium sheet.
3. Plant specimens, which have been properly mounted and identified, are filed systematically in an expandable envelope.

DATA AND RESULTS

FLORA OF BATANGAS
Pantay Matanda, Tanauan City, Batangas

Family: ______________________________ **Field No.:**______
Scientific Name:_________________________________
Local Name and Dialect: ____________________________
Collector's Name: ______________________________
Locality: ____________________________________
Habitat: ____________________________________
Habit Description: ______________________________
____
____
Economic Use: ________________________________
____

GUIDE QUESTIONS

1. What is the importance of preserving plants through herbarium?

2. Other than leaf, what other parts of the plant can we preserve using plant press?

3. How do we mount small-sized plant samples like moss, algae, lichens etc?

4. Why is it important to have field notes during field collection of samples?

5. Aside from drying, what can we do in order to prolong the shelf-life of our herbaria?

APPLICATION

In this digital age where access and availability of information is just a click away, would you still promote the use of herbarium? Why or why not? Support your answer.

CONCLUSION

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"The chief work of the botanists of yesterday was the study and classification of dried shriveled plant mummies whose souls had fled."

- *Luther Burbank*

Activity 12: Floral Variations

INTRODUCTION

For us humans, flowers play a significant role in adding beauty to our surroundings, for expressing our feelings to our loved ones or even using it as a subject for composing poems, songs and various artworks. But for plants, flowers are their means of producing seeds to continue propagating their species. In our previous activity, you learned that leaves of plants vary in terms of color, shape and size to name a few.

In this activity, you will discover that just like leaves, the flowers of a plant may also exhibit variation.

YOUR TASKS

At the end of the activity, you should be able to:

1. Identify the parts of a flower and their function;
2. Classify flower as perfect or imperfect, simple or compound; and
3. Recognize the importance of variation in flower structure in plants.

THINGS NEEDED

Samples of flower from available plants in the home garden (e.g.
Forceps
Blade/scalpel
Handlens

WHAT TO DO

Obtain at least 5 different samples of flower in your home garden.
2. Examine the sepals, petals, and receptacle.
3. Using forceps and blade or scalpel, dissect the flower and study its internal parts.
4. Classify your sample flowers according to:
    a. *Composition*: simple or compound
    b. *Symmetry*: regular or irregular flower
    c. *Presence/absence of male and/or female sexual organ(s)*: perfect or imperfect
    d. *Presence/absence of all floral parts (sepal, petal, stamen and pistil* : complete or incomplete
5. Complete the table on the next page.

DATA AND RESULTS

Specimen	based on composition	Based on symmetry	based on sexual organ present	based on floral parts present
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				

GUIDE QUESTIONS:

1. What are the essential and non-essential parts of the flower?

2. From your flower samples, which are the regular flower? irregular flower?

3. Which among your flower samples has complete parts? incomplete parts?

4. Using the information you obtained on the number of floral parts, which plants are monocot? a dicot? What can you deduce from this?

5. Give some features of flowers that makes them attractive to man and to pollinators.

APPLICATION

Do all flowering plants bear fruit? Support your answer.

CONCLUSION

"Even if you think the Big Bang created the stars, don't you wonder who sent the flowers?"

- Robert Brault

Activity 13: Energy Flow in the Home Garden

INTRODUCTION

All living things require energy to survive, thus the flow of energy in biological communities depend on the nutritional relationships between organisms. In this activity, you will learn how organisms obtain energy and how this energy is being transferred from one organism to another through food chain and food web. Also, you will discover how the reduction in the amount of available energy limits the number of steps that can occur in a food chain.

YOUR TASKS

In this activity, you should be able to:

1. Identify the ecological niche (role) of a particular organism.
2. Illustrate the flow of energy in the school garden through food chain and food web; and
3. Value the ecological importance of every organism on earth and their right to exist.

THINGS NEEDED

Ballpen
Reference book

WHAT TO DO

1. Given below are the list of possible organisms that you can find in your home garden.

Centipede	Grasshopper	Lady bug
Tomato plant	Maya bird	Snake
Aphids	Pechay	Ants
Frog	Earthworm	Bees
Chicken	Caterpillar	Spider
Alugbati	Grass	butterfly

Table 1. Common organisms that can be found in a home garden

2. Construct a food web using the organisms listed on the table above.
3. From your illustrated food web, identify the ecological role (niche) played by each organism by completing the table 2.

DATA AND RESULTS

Figure 1. Simplified Food web in our Home Garden

Table 2. Classification of organisms based on their ecological role played in an ecosystem

Producer	First order consumer	Second order consumer	Third order consumer	Final consumer

GUIDE QUESTIONS

1. How many food chains can you identify from your food web? List them down.

2. Using the illustration you have made in figure 1, how will you differentiate a food chain and a food web?

3. What would happen if the population of aphids and caterpillar increase in size? What if the population of frog declines?

4. Which organism/s listed in Table 1 is/are the decomposer? What important role do they play in your ecosystem (home garden)?

5. Why do you think that the number of organisms in a food chain is limited to 4 or 5 organisms only?

APPLICATION

Explain how flow of energy and productivity in your home garden related?

CONCLUSION

Activity 14. Relationship Status? It's Biotic-Biotic!

INTRODUCTION

"No man is an island". This saying is also true for organisms in an ecosystem. No organisms exists in isolation. Individual organisms live together in an ecosystem and depend on one another. In fact, they have many different types of interactions with each other, and many of these interactions are critical for their survival since it may describe how organism obtain their food and energy.

In this activity, you will learn the different ecological interactions such as competition, predation, parasitism, commensalism, mutualism and amensalism.

YOUR TASKS

At the end of this activity, you should be able to:

1. Identify the different biotic interactions that may exists in home garden.
2. Differentiate the types of biotic interaction based on how organisms interact with one another.
3. Value every organisms in our surroundings since they have a significant role to play.

THINGS NEEDED

Pen
Cellphone with camera
Activity sheet

WHAT TO DO

1. Visit your home garden and carefully observe the different organisms present and how do they interact with one another.
2. Take a photo documentation of the organisms involved in the interaction.
3. Fill-in the table with the necessary information.

   Colum 1: Place the picture of the organisms that you have identified.
   Column 2: Identify the type of ecological (biotic) relationship present
   Column 3: Write a short description of the type of interaction.
   Column 4 and 5: Using the following symbols, tell what happen to the interacting organisms involved:

   ☺- benefitted
   ☹- harmed
   😐- neither benefitted nor harmed

DATA AND RESULTS

PICTURE	TYPE OF BIOTIC INTERACTION	DESCRIPTION	ORGANISM 1	ORGANISM 2

GUIDE QUESTIONS

1. What are the common types of ecological relationship have you identified in your home garden?

____
____
____
____

2. How would interspecific and intraspecific competition happen in your home garden?

____
____
____
____

3. What is herbivory? What type of biotic interaction is it?

____
____
____
____

4. Differentiate predation and parasitism.

5. Discuss the significant role of insects (e.g. butterflies and bees) in your garden.

APPLICATION

Species may be introduced, accidentally or intentionally into an area that is not part of their natural habitat. These are called alien or introduced species. Suppose that an alien species of plant was introduced into an area during tree planting activity. How may this alien species affect the native populations of plant in that particular habitat?

CONCLUSION

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"All things are bound together. All things CONNECT. Whatever happens to the EARTH, happens to the CHILDREN of the EARTH. Man did not weave the WEB of LIFE, he is merely a strand in it. Whatever he does to the earth, he does to himself."

– Chief Seattle

SUGGESTED YOUTUBE LINKS TO WATCH:

TOPIC	LINK
Act.2 - Investigating Plant Cells	https://www.youtube.com/watch?v=GLxFpNsvYOU&t=4s https://www.youtube.com/watch?v=dxv4M4HHUgs
Act. 3- You Light Up my Leaf	https://www.youtube.com/watch?v=YtvyFOvbau8
Act. 4- Investigating Photosynthesis	https://www.youtube.com/watch?v=vw8baZO89oc&feature=youtu.be
Act 5. From seed to seedling	https://www.youtube.com/watch?v=6_uRLam8uTA
Act.6 Propagating Plants through Stem Cuttings	https://www.youtube.com/watch?v=ldv-nzdE2aM https://www.youtube.com/watch?v=G_YoCbePFRg
Act. 7 Leaf Morphology	https://www.youtube.com/watch?v=5Sd7uRSCQ4E
Act. 10 Grow a Garden in a SNAP	https://www.youtube.com/watch?v=PaoMduWaaPo
Act. 11 Making Your Own Herbarium	https://www.youtube.com/watch?v=TWQhP5IAgWU

Appendix F: Validated Learning Engagement Survey Questionnaire

LEARNING ENGAGEMENT SURVEY QUESTIONNAIRE

This is 41-item researcher made instrument containing items about the reported components of students' learning engagement (pooled from literature), which was replaced by the word "life science", such as cognitive engagement (factor I), affective engagement (factor II) and behavioral engagement (factor III). Students' responses will be FACTOR ANALYZED (exploratory) to extract the COMPONENTS of their learning engagement towards biological science.

Responses are categorized along a four-point Likert type scale: 1- strongly disagree, 2- disagree, , 3- agree, 4- strongly agree.

Directions for the respondents will be worded as these:

Directions: For each of the statements below expresses the level of engagement in science class. Please rate the statement on the extent to which you agree. For each, you may strongly disagree (1), disagree (2), be undecided (3), agree (4) and strongly agree (5). There is no right or wrong answer. This is not a test and therefore will not be scored. This will not affect your grade in your Earth and Life Science. Encircle the number code as best and as honest as possible.

Dear Validator,

Kindly validate if the following items are relevant in measuring the level of learning engagement of students in their science class. Mark only one oval per row.

Factor	With the garden-based learning in Biology…..	SD	D	A	SA
II	I. I enjoy discovering and learning new things	▢	▢	▢	▢
III	2. I put enough effort into learning the life science concepts and theories	▢	▢	▢	▢
I	3. I figure out how the information I learned might be useful in the real world.	▢	▢	▢	▢
III	4. When I am in my class, my mind wanders.	▢	▢	▢	▢
III	5. I finish my learning tasks on time.	▢	▢	▢	▢
II	6. I feel so lazy or bored when I study my modules that I don't finish what I planned to do.	▢	▢	▢	▢
III	7. I prepare well for my tests/ experiments.	▢	▢	▢	▢
I	8. When the topic is hard, I only study the easy parts.	▢	▢	▢	▢
II	10. If I am having trouble learning science topics, I ask help from my classmates or teacher.	▢	▢	▢	▢
I	11. I try to see the similarities and differences between things I am learning and things that I already know.	▢	▢	▢	▢
II	12. I keep on working even the learning tasks are uninteresting.	▢	▢	▢	▢
I	13. I try to understand how things I learn in school fit together with each other.	▢	▢	▢	▢
III	14. If I don't understand my lessons, I give up right away.	▢	▢	▢	▢
II	15. Understanding the lessons give me the sense of accomplishment.	▢	▢	▢	▢
III	16. I prepare well for the tests and activities /experiments.	▢	▢	▢	▢
I	17. Before I start doing my assignments, I plan out how I am going to do it.	▢	▢	▢	▢
II	18. The knowledge and skills I learn is more important to me than the grade I receive.	▢	▢	▢	▢
III	19. I allot 2-3 hours per day in studying this subject.	▢	▢	▢	▢

I	20. I try to think through topics and decide what I'm supposed to learn from them, rather than studying topics by just reading them over.	▢	▢	▢	▢
I	21. When learning things in this subject, I often try to understand the material better by relating it to things I already know.	▢	▢	▢	▢
III	22. I use strategies to ensure that I learn the subject well.	▢	▢	▢	▢
II	23. I hate taking science tests.	▢	▢	▢	▢
II	24. I don't want to be in a science class.	▢	▢	▢	▢
II	25. I easily get frustrated when I get low score in the tests, activities or experiments.	▢	▢	▢	▢
I	26. I would rather be told the answers in our activities than have to do the work.	▢	▢	▢	▢
III	27. When I am in my class, I participate actively in the discussion.	▢	▢	▢	▢
III	28. When I answer difficult homework in life science, I keep working at it until I've solved it.	▢	▢	▢	▢
I	29. When learning science, I often try to associate them with what I learnt in other classes about the same or similar things.	▢	▢	▢	▢
III	30. When I am in my science class, I just act like I'm working.	▢	▢	▢	▢
II	31. I am very interested in learning science.	▢	▢	▢	▢
I	32. When I study science subject, I try to connect what I am learning with my own experience.	▢	▢	▢	▢
I	33. I make up my own examples to help me understand the important concepts I learn from my science class.	▢	▢	▢	▢
III	34. During class discussion, I pay attention to my teacher.	▢	▢	▢	▢
I	35. When learning new information, I try to put the ideas in my own words.	▢	▢	▢	▢
II	36. I feel nervous when I am in my science class.	▢	▢	▢	▢
I	37. I like to do better in science because I want to take science-related course in college.	▢	▢	▢	▢
II	38. When I am in my science class, I keep on working hard even if I do not like what I am doing.	▢	▢	▢	▢
III	39. When I need to, I put school work before other activities, like playing ML, using social media etc.	▢	▢	▢	▢
III	40. I ask my teacher to clarify concepts that I do not understand.	▢	▢	▢	▢
II	41. Even if the learning modules are dull and uninteresting, I manage to keep working until I finish it.	▢	▢	▢	▢

Appendix G: Adopted Attitude Towards Biology Questionnaire

ATTITUDE TOWARDS BIOLOGY SURVEY QUESTIONNAIRE (ATBSQ)

This is a 50-item adopted research instrument with permission from the author, containing items about the reported components of students' attitude towards the science (pooled from literature). Each statement can be categorized into seven factors such as: importance of biology (factor I), interest in biology lessons (factor II), perception of the biology teacher (factor III), keenness to learn biology (factor IV), enjoyment of biology (factor V), anxiety towards biology (factor VI) and effort in learning biology (factor VII)

Responses are categorized along a five-point Likert type scale: 1- strongly disagree, 2- disagree, 3- be undecided, 4- agree, 5- strongly agree.

Directions for the respondents will be worded as these:

Directions: For each of the statements below expresses the level of engagement in science class. Please rate the statement on the extent to which you agree. For each, you may strongly disagree (1), disagree (2), be undecided (3), agree (4) and strongly agree (5). There is no right or wrong answer. This is not a test and therefore will not be scored. This will not affect your grade in your Earth and Life Science. Encircle the number code as best and as honest as possible.

Dear Validator,

Kindly validate if the following items are relevant in measuring the level of learning engagement of students in their science class. Mark only one oval per row.

Factor		SD	D	A	SA
I	1. Everybody needs knowledge of biology.	▢	▢	▢	▢
I	2. Biology helps me in the development of my conceptual skills	▢	▢	▢	▢
V	3. Biology is a very interesting subject.	▢	▢	▢	▢
I	4. Biology is an important part of our lives.	▢	▢	▢	▢
V	5. Biology is boring.	▢	▢	▢	▢
V	6. Biology is fascinating and fun	▢	▢	▢	▢
I	7. Biology is our hope for solving many environmental issues and problems.	▢	▢	▢	▢
II	8. Biology lessons become a source of boredom for me.	▢	▢	▢	▢
VI	9. Biology makes me feel uncomfortable, restless, irritable and impatient.	▢	▢	▢	▢
IV	10. During biology lectures, I can comprehend the important points.	▢	▢	▢	▢
VI	11. For me, biology seems scary.	▢	▢	▢	▢
VII	12. I always try hard no matter how difficult the lesson in biology is.	▢	▢	▢	▢
VII	13. I always try to do best in biology.	▢	▢	▢	▢
VI	14. I am always in terrible strain in a biology class.	▢	▢	▢	▢
V	15. I am looking forward to our biology class.	▢	▢	▢	▢
VI	16. I approach biology with a feeling of hesitation.	▢	▢	▢	▢
IV	17. I can explain biology concepts in my own words.	▢	▢	▢	▢
IV	18. I can focus in biology lessons.	▢	▢	▢	▢
II	19. I cannot understand the biology lessons after class.	▢	▢	▢	▢
IV	20. I complete first my homework in biology before doing other things.	▢	▢	▢	▢
III	21. I consult my biology teacher in any topic/s that I cannot understand during science class.	▢	▢	▢	▢

II	22. I do not have the interest to complete my homework in biology.	☐	☐	☐	☐
II	23. I do not have the interest to discuss biology topics after the school time.	☐	☐	☐	☐
V	24. I enjoy learning biology.	☐	☐	☐	☐
III	25. I enjoy talking to my biology teacher after class.	☐	☐	☐	☐
V	26. I feel a definite positive reaction to biology because it is enjoyable.	☐	☐	☐	☐
I	27. I find biological process very interesting.	☐	☐	☐	☐
IV	28. I follow a regular time schedule to study biology at home.	☐	☐	☐	☐
IV	29. I fully concentrate on the topic discussed in my biology class.	☐	☐	☐	☐
II	30. I hate biology lesson.	☐	☐	☐	☐
I	31. I make many efforts to understand biology.	☐	☐	☐	☐
V	32. I really like biology.	☐	☐	☐	☐
IV	33. I review lessons in biology daily at home.	☐	☐	☐	☐
VII	34. I try hard to do well in biology.	☐	☐	☐	☐
III	35. I understand biology lessons taught in class by the teacher.	☐	☐	☐	☐
IV	36. I usually relate the previously learned lessons in biology with the new one.	☐	☐	☐	☐
V	37. I would enjoy being a biologist.	☐	☐	☐	☐
II	38. I would not probably do well in course related to biology.	☐	☐	☐	☐
I	39. Knowledge in biology is essential for understanding other courses and phenomena.	☐	☐	☐	☐
III	40. My biology teacher encourages me to learn more about biology.	☐	☐	☐	☐
III	41. My biology teacher makes a good plan for us.	☐	☐	☐	☐
II	42. My mind goes blank when I am studying biology.	☐	☐	☐	☐
III	43. The important points emphasized by my teacher during class discussion helps me in learning biology.	☐	☐	☐	☐
II	44. The lessons taught in biology are not interesting.	☐	☐	☐	☐
I	45. The progress of biology improves the quality of our lives.	☐	☐	☐	☐
I	46. The work with living organisms in biology lessons is very interesting.	☐	☐	☐	☐
III	47. We do a lot of fun activities in biology class.	☐	☐	☐	☐
I	48. We learn important things in biology class.	☐	☐	☐	☐
VII	49. When I fail in biology exam, I always try much harder.	☐	☐	☐	☐
VI	50. When I hear the word “biology”, I have a feeling of dislike.	☐	☐	☐	☐

Appendix H: Validated Questionnaire on Students' Perception Towards GBL

Questionnaire on Students' Perception Towards GBL

DIRECTIONS: The following statements describe the Garden-based learning used as a strategy in teaching life science subject. Please read them carefully and answer the following statements so that the information provided reflects your assessment on the use of the strategy. Rate the statements from 4 to 1 with 1 being the lowest and 4 being the highest. Encircle the number that corresponds to your rating.

The activities I had in home gardening…….	**Strongly disgree (1)**	**Disgree (2)**	**Agree (3)**	**Strongly Agree (4)**
21. improved my academic performance in life science	O	O	O	O
22. enhanced my critical thinking skills	O	O	O	O
23. developed my positive attitude towards environment	O	O	O	O
24. enhanced my interpersonal skill	O	O	O	O
25. increased my willingness to take science related course in college	O	O	O	O
26. fostered positive attitude towards life science	O	O	O	O
27. increased my appreciation in learning life science	O	O	O	O
28. taught me to become patient and responsible	O	O	O	O
29. offered a symbolic locus of personal pride and spirit	O	O	O	O
30. allowed me to see the practical application of life science topics	O	O	O	O
31. gave me the opportunity to explore my natural world	O	O	O	O
32. enhanced my science process skills (e.g. experimenting, inferring, measuring etc.)	O	O	O	O
33. improved my attitude towards schooling	O	O	O	O
34. inspired me to create vegetable garden at home	O	O	O	O
35. increased my self-esteem and self-efficacy	O	O	O	O
36. allowed me to develop perseverance and open-mindedness	O	O	O	O
37. answered my curiosity about biology concepts	O	O	O	O
38. made me realize the importance of responsibility in taking care of my environment.	O	O	O	O
39. increased my appreciation in learning biology	O	O	O	O
40. created a learning environment that fostered cooperation and collaboration	O	O	O	O

Appendix I. Validated Life Science Achievement Test (LSAT)

Pantay Integrated High School

Grade- 11

LSAT

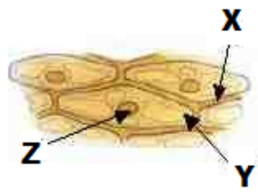
Life Science Achievement Test

LIFE SCIENCE ACHIEVEMENT TEST (LSAT)

Directions: On the answer sheet provided, shade the circle that corresponds to the letter of the correct answer. Do not leave any item unanswered.

I. CHARACTERISTICS OF LIVING THINGS

1. Plant cytology is ______
   A. the science that deals with plant fossils.
   B. concerned with the various diseases of plants.
   C. the study of structure and function of plant cells.
   D. the scientific way of classifying and naming of plants.
2. The following statements below holds TRUE for all living things EXCEPT:
   A. All living things move.
   B. All living things are made up of cells.
   C. All living things adapt to their environment.
   D. All living things undergo growth and development.
3. Growth in plants is achieve when there is an increase in the _____
   A. size of cells C. spaces between cells
   B. number of cells D. size and number of cells
4. What characteristic of living things is being shown by *Mimosa pudica* (makahiya) when its leaflets fold upward when touched?
   A. adaptation C. growth
   B. development D. response to the environment
5. A tomato plant begins its life as a seed and then overtime grows as a fruit-bearing plant. Which of the following characteristics of life is being exhibited by tomato plant?
   A. highly organized C. grow and develop
   B. obtains energy D. respond to stimulus
6. The diagram shows a group of onion cells. The parts labelled X, Y and Z respectively are _______
   A. X= cytoplasm, Y = cell wall, Z = nucleus
   B. X = nucleus, Y= cell wall, Z = cytoplasm
   C. X = cell wall, Y = cytoplasm, Z = cell membrane
   D. X = cell wall, Y = cytoplasm, Z = nucleus

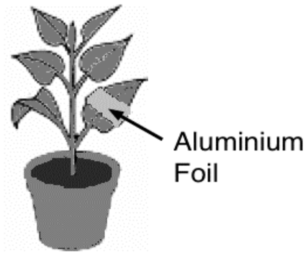


7. Which of the following is NOT a premise of cell theory?
   A. All cells arise from pre-existing cells through cell division.
   B. All living cells require energy in order to survive.
   C. All living things are made up of a eukaryotic cell.
   D. Cell is the basic structural and functional unit of life.
8. The growth of plant's roots in the direction of the force of gravity is an example of _____.
   A. photoperiodism C. phototropism
   B. thigmotropism D. geotropism
9. Which of the following is NOT an adaptation of plants for them to survive in the desert?
   A. have spines C. succulent (fleshy) stems
   B. shallow, expansive root system D. needle-like leaves
10. Which is the correct sequence that represents the levels of organization in an organism from the biggest (most complex) to smallest (least complex) level?
   A. cell → organ → organ system → tissue
   B. organ → organ system → tissue → cell
   C. tissue → cell → organ → organ system
   D. organ system → organ → tissue → cell

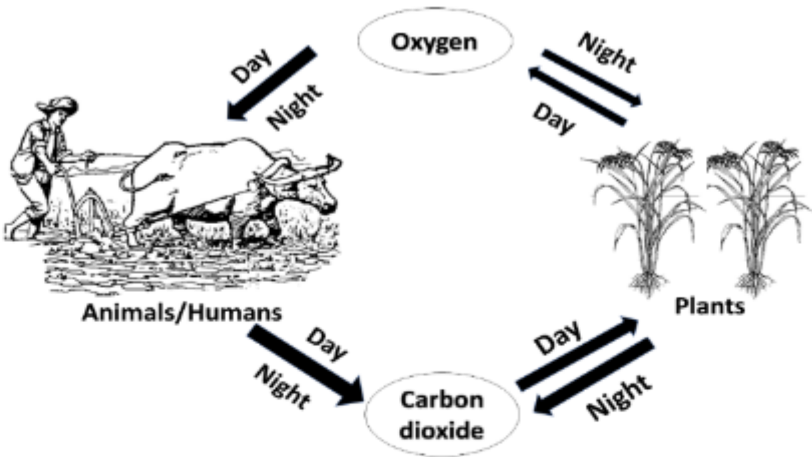
II. PHOTOSYNTHESIS

1. Which of the following environmental conditions would likely increase the rate of photosynthesis?
   - A. increase in nitrogen concentration
   - B. increase in oxygen concentration
   - C. increase in carbohydrate concentration
   - D. increase in carbon dioxide concentration
2. Where does the oxygen during photosynthesis come from?
   - A. splitting of carbon dioxide
   - B. splitting of water
   - C. formation of glucose
   - D. formation of ATP
3. Why do leaves of kankong plant, *Ipomea aquatica*, appear green?
   - A. Because its chlorophyll absorbs green light.
   - B. Because its chlorophyll reflects green light.
   - C. Because its chlorophyll absorbs both blue and green light.
   - D. Because its chlorophyll reflects both blue and green light.
4. What is the main energy-trapping molecule in plant cells?
   - A. carotenoids
   - B. chloroplast
   - C. chlorophyll
   - D. stroma
5. Oxygen and carbon dioxide are gases that cycle out in the ecosystem. Which of the following gases is important to photosynthesis?
   - A. carbon dioxide
   - B. oxygen
   - C. ozone gas
   - D. water vapor
6. In what way are photosynthesis and cellular respiration different?
   - A. Cellular respiration stores ATP, while photosynthesis releases ATP.
   - B. Photosynthesis releases energy, while cellular respiration stores energy.
   - C. Cellular respiration produces oxygen, while photosynthesis uses oxygen.
   - D. Photosynthesis uses carbon dioxide, while cellular respiration produces carbon dioxide.
7. Sugarcane juice is used in making table sugar which is extracted from the stem of the plant. Trace the path of sugar molecules found in the stem from where they are produced?
   - A. leaf → stem
   - B. leaf → stem → roots
   - C. root→ leaf → stem
   - D. flower → leaf → stem
8. Which of the following molecule is released as by-product of the light-independent reactions of photosynthesis?
   - A. Water (H_2O)
   - B. glucose ($C_6H_{12}O_6$)
   - C. carbon dioxide (CO_2)
   - D. adenosine triphosphate (ATP)
9. Abby wants to know if leaves are capable of making food during nighttime. Which of the following experimental design should Abby do to get an accurate answer to her question?
   - A. Cover the plant with paper bag overnight and test for the presence of starch.
   - B. Put one potted plant in a very dark place overnight and test for the presence of starch
   - C. Put one potted plant under the sun and the other in a shaded area for two hours and test for the presence of starch.
   - D. Cover one leaf of a potted plant with carbon paper for two hours and test for the presence of starch.
10. Which of the following organisms contain chloroplasts in their cells?
    - A. butterfly
    - B. mushroom
    - C. eggplant
    - D. earthworm
11. Which of the following plant cell structure-function is MISMATCHED?
    - A. nucleus – stores genetic material
    - B. cytoskeleton- provides rigidity and shape
    - C. chloroplast- produces ATP
    - D. Golgi- secretes cell products

12. The plant shown in the diagram was left in total darkness for three days and then exposed to strong sunlight for one day. The leaf with the foil was removed from the plant and tested for starch with iodine solution. Which one of the following is most likely to happen?
    A. All of the leaf goes blue/black.
    B. The covered part of the leaf goes blue/black.
    C. The uncovered part of the leaf goes blue/black.
    D. None of the leaf goes blue/black.

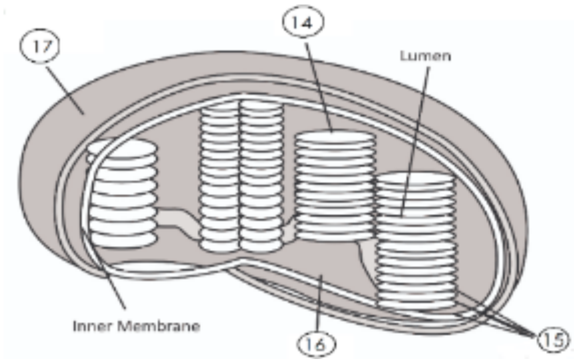


Use the illustration below to answer item no. 13.



13. All of the following statements can be inferred from the illustration. Which one is INCORRECT?
    A. Plants and animals depend on each other for oxygen and carbon dioxide.
    B. During the day, plants take in carbon dioxide and give off oxygen in the air.
    C. At nighttime, both plants and animals take in oxygen and give off carbon dioxide in the air.
    D. Plants give off carbon dioxide needed by animals and in turn, animals give off oxygen needed by plants.

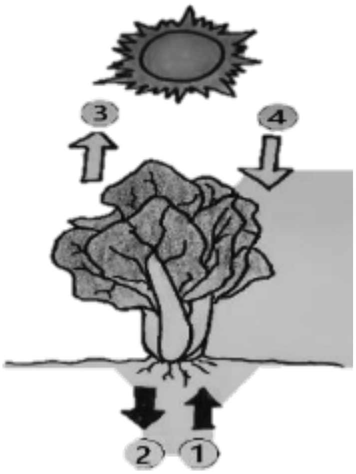
For numbers 14-17, refer to the illustration of chloroplast below. Choose the parts of the organelle labeled by each number.



A. stroma
B. granum
C. thylakoid
D. outer membrane

18. Which of the following organisms are heterotrophs?
    A. ferns
    B. mosses
    C. grasses
    D. mushrooms

19. After studying photosynthesis, Rabiya drew the illustration of a tomato plant shown below.



Which arrow represents where the primary release of oxygen (O_2) occurs?

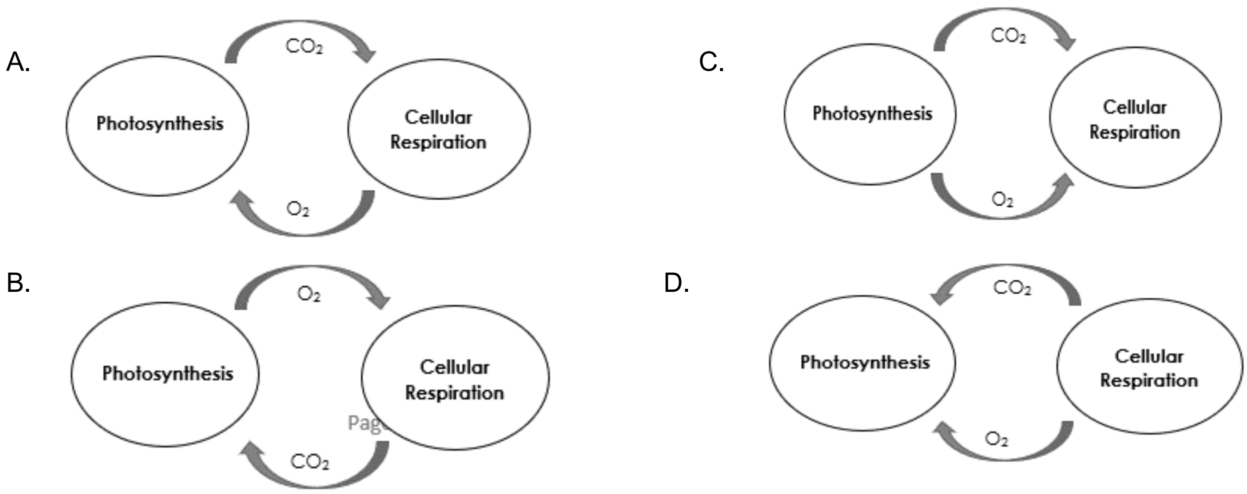
A. 1
B. 2
C. 3
D. 4

20. Organisms that can make their own food via photosynthesis are called photoautotrophs. Which of the following organisms are examples of photoautotrophs?

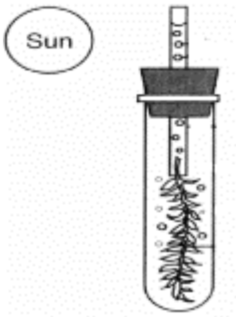
I. Alugbati
II. Okra
III. pechay
IV. caterpillar
V. snail

A. IV and V only
B. III only
C. I, II and III only
D. I, II, III, IV, and V

21. Which of diagram below accurately represents the exchange of gases during photosynthesis and cellular respiration?



22. Haliya placed a small water plant in bright sunlight for five hours as indicated in the set-up below. She observed bubbles being released from the plant.

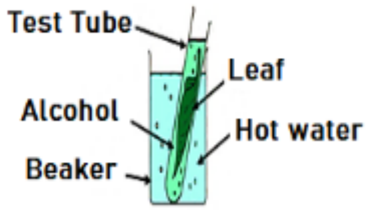


If these bubbles were oxygen gas, it can be inferred that the plant is _________.

A. respiring
B. transpiring
C. producing carbohydrates
D. releasing energy from water

23. During an experiment to test a green leaf for starch, at one stage the leaf is soaked in warm alcohol for about 10 minutes. What is the purpose of this?

A. To test if the alcohol is volatile.
B. To kill any bacteria on the leaf.
C. To kill the cells in the leaf.
D. To remove chlorophyll from the leaf.



24. A student investigated the effect of temperature on the rate of photosynthesis in a water plant. The results are shown in the following table.

Temperature (^0C)	*Volume of oxygen released per cm^3 per 5 minutes*
5	*2*
15	*4*
25	*7*
35	*10*
45	*12*

Which of the following statements accurately describes the relationship between temperature and rate of photosynthesis?

A. At 45^0C, the water plant produced the most amount of oxygen.
B. As the temperature increases, the amount of carbon dioxide absorbed by the plant also increases.
C. As the temperature increases, the rate of photosynthetic activity becomes faster.
D. As the temperature increases, the amount of oxygen released by the plant doubles.

25. Which one of the following word equations best describes the process of photosynthesis?

A. Water + Carbon dioxide $\xrightarrow[\text{glucose}]{\text{light}}$ Chlorophyll + Oxygen

B. Carbon dioxide + Oxygen $\xrightarrow[\text{chlorophyll}]{\text{light}}$ Carbohydrates + water

C. Carbon dioxide + Water $\xrightarrow[\text{chlorophyll}]{\text{light}}$ Carbohydrates + Oxygen

D. Water + Oxygen $\xrightarrow[\text{chlorophyll}]{\text{light}}$ Carbohydrates + Carbon dioxide

III. PLANT REPRODUCTION

1. Corn (*Zea mays*) is an example of a monoecious plant. It is considered monoecious because ____
   A. It has flower that contains both stamen and pistil
   B. It contains only one type of unisexual flower either staminate or pistilate
   C. It contains both the pistilate and staminate flowers together in one plant body
   D. It has a flower whose petals are fused together to form a single piece called a corolla tube.
2. In plants, the fusion of male and female sex cells (gametes) from different individuals of the same species is called ______.
   A. asexual reproduction C. self-fertilization
   B. cross-fertilization D. sexual reproduction
3. Gabi, ubi and gladiolas reproduce asexually by formation of
   A. corm C. sucker
   B. tuber D. rhizome
4. Which part of the seed embryo will give rise to the shoot system of the plant?
   A. cotyledon C. hypocotyl
   B. epicotyl D. stipules
5. Which one of the following is the correct order in which a flowering plant may reproduce?
   A. Germination, pollination, seed dispersal, fertilization, seed formation.
   B. Fertilization, pollination, germination, seed dispersal, seed formation.
   C. Pollination, seed formation, fertilization, germination, seed dispersal.
   D. Pollination, fertilization, seed formation, dispersal, germination.
6. Which of the following external factors is NOT needed by a mongo seed in order for it germinate?
   A. light C. source of moisture
   B. temperature D. production of ethylene
7. Grafting is widely used for propagating plants because the resulting plant _______
   A. becomes more pest resistant.
   B. bears abundant fruits more frequently.
   C. bears fruit faster than the seed-grown plants.
   D. combine the desirable traits of the two sources.
8. Organisms produced by genetic engineering are different from organisms produced by sexual reproduction because______.
   A. chemicals are used
   B. defective genes are replaced
   C. they do not undergo fertilization
   D. better and more fertile offspring are produced

9. All but one is an agent of pollination?
   - A. soil
   - B. wind
   - C. insects
   - D. humans
10. Which of the following vegetative structures for reproduction is a specialized leaf?
    - A. onion bulb
    - B. potato tuber
    - C. rhizome of ginger
    - D. stolon of carabao grass
11. All of the following are female parts of a gumamela flower EXCEPT for:
    - A. style
    - B. anther
    - C. ovary
    - D. stigma
12. Pollination occurs when ________.
    - A. pollen lands on a stigma
    - B. a sperm fuses with an egg
    - C. insect sips nectar from a flower
    - D. a pollen grain releases sperm cells
13. What is the most important function of genetic engineering?
    - A. To improve species
    - B. To create plants which are pest-resistant
    - C. to cure all known diseases
    - D. to produce any desired product
14. Which of the following differentiates asexual reproduction from sexual reproduction?
    - A. Asexual reproduction requires gametes while sexual reproduction requires body parts.
    - B. Asexual reproduction undergoes fertilization while sexual reproduction undergoes binary fission.
    - C. Asexual reproduction does not require gametes while sexual reproduction requires the union of gametes.
    - D. Asexual reproduction produces offspring which is different from the parent while sexual reproduction produces offspring identical to the parent.

IV. PLANT FORM AND FUNCTION

1. Where can you find the highest concentration of chloroplasts in a typical leaf?
   - A. epidermis
   - B. vascular tissue
   - C. spongy mesophyll
   - D. palisade mesophyll
2. Which organ of a plant is involved in photosynthesis and transpiration?
   - A. root
   - B. stem
   - C. leaves
   - D. flowers
3. Alugbati or Malabar spinach (*Basella alba*), is an indigenous green-leafy vegetable in the region of CALABARZON. What is the shape of the blade (lamina) of alugbati leaf?
   - A. lanceolate
   - B. deltoid
   - C. cordate
   - D. reniform

4. Which of structure comes out first from a germinating pechay seed?
   - A. true leaves
   - B. embryonic root
   - C. embryonic shoot
   - D. seed leaves or cotyledons
5. What is the main function of the xylem and phloem?
   - A. storage
   - B. absorption
   - C. transport
   - D. photosynthesis
6. Which of the following molecules are being transported by phloem?
   - A. water
   - B. sucrose
   - C. dissolved minerals
   - D. oxygen and carbon dioxide

7. Which of the following are the primary functions of plant roots?

I. Anchorage
II. Absorption of water and minerals
III. Storage of food molecules
IV. Absorption of carbon dioxide and other gases

A. I and II only
C. I, II and III only
B. II and III only
D. I, II, III and IV

8. Analyze the two statements below to answer item number ___

I. The blade (lamina) is the expanded portion of the leaf and is usually colored green.
II. The leaf is attached to the stem by a petiole.

A. Both statements are correct.
B. Both statements are incorrect.
C. The first statement is correct, while the second statement is incorrect.
D. The first statement is incorrect, while the second statement is correct.

9. Which of the these are plant structure- function NOT correctly matched?

A. ovary- ripens into fruit
C. pistil- produces pollen grain
B. ovule- becomes seed
D. ovary wall- develops into pericarp

10. Some weeds are anchored by taproots. They cause problems to gardeners because they are___.

A. easy to pull up because the root system is shallow.
B. difficult to pull up because their taproots penetrate deep into the soil.
C. difficult to pull up because they are anchored by an extensive network of roots.
D. easy to pull up because well-developed primary and secondary roots are not present.

11. If a gardener trims leaves off of the stem of a rose, which part of the leaf is cut?

A. petiole
C. stipule
B. lamina
D. midrib

12. Which of the following statements explains the opening of the stomata?

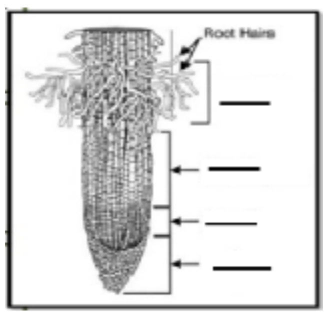
A. Water leaves the leaf through the stomata.
B. Carbon dioxide enters the leaf through the stomata.
C. The guard cells become turgid due to diffusion of water into them.
D. The guard cells become turgid due to diffusion of water out of them.

13. Which of the following has an herbaceous stem?

A. citrus
C. eggplant
B. tomato
D. malunggay

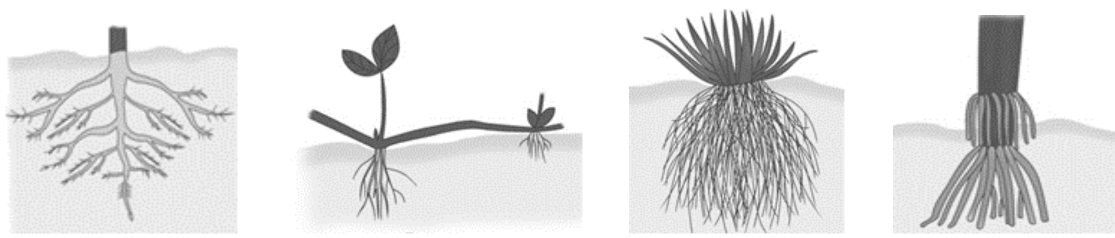
14. Which of the following is the CORRECT sequence of the longitudinal section of a root from tip upward? Refer to the items I to IV inside the box to answer this question.

I. Zone of elongation
II. Zone of maturation
III. Apical meristem
IV. Root cap

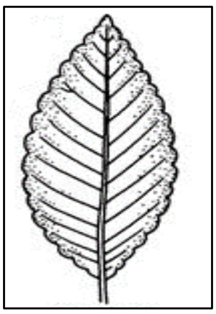


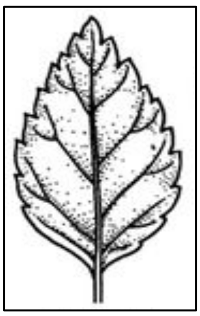
A. III, II, I IV,
C. IV, III, I, II
B. II, I, III, IV
D. I, II, III, IV

15. Which of the illustration below shows a fibrous root system?



16. If you would grow plants using hydroponics gardening method, which of the following plants are you going to use?
    A. lettuce, pechay, kangkong
    B. raddish, carrots, ginger
    C. tomato, cassava, cucumber
    D. lettuce, basil, okra
17. Of all the environmental factors below, which is the most influential in determining the rate of transpiration of plants?
    A. Light
    B. relative humidity
    C. temperature
    D. water
18. Why does some plants have thorns?
    A. To provide shade for the plant.
    B. To take in nutrients from the air.
    C. To stay safe from animals that want to eat them.
    D. To attract insects that spread pollens to other plants.
19. What might some plants that grow on the shady rainforest floor have large leaves?
    A. To stay safe from predators
    B. To attract different animals
    C. To take in as much sunlight as possible
    D. To survive harsh winters with heavy snowfalls
20. While in the garden, students collect few samples of leaves for their activity in their Earth and Life Science subject. One student picks a blade of grass and identifies it as a dicot leaf, but his partner thinks it is a monocot. Which explanation would support his partner's opinion?
    A. The leaf has a large and expanded leaf blade.
    B. There is no petiole.
    C. The leaf margins are serrated.
    D. The leaf has a parallel venation.
21. What is the function of the stolon of carabao grass?
    A. support
    B. food storage
    C. reproduction
    D. water preservation
22. The age of a tree can be determined by counting the:
    A. number of leaves
    B. number of annual rings
    C. number of roots
    D. number of branches
23. Which of the following phytohormone-function pairs is INCORRECT?
    A. Ethylene- promotes fruit ripening
    B. Gibberellins- breaks seed dormancy
    C. Cytokinins- prevent premature dropping of fruits
    D. Abscisic acid- closes stomata during water stress
24. Which of the illustrations below shows a leaf with serrated (toothed) margin?






25. Eggplant or talong is a dicot plant. Which of the following is TRUE about the internal arrangement of vascular bundles of the stem of eggplant?
    A. arranged in ring
    B. compactly arranged
    C. scattered throughout
    D. has numerous spaces

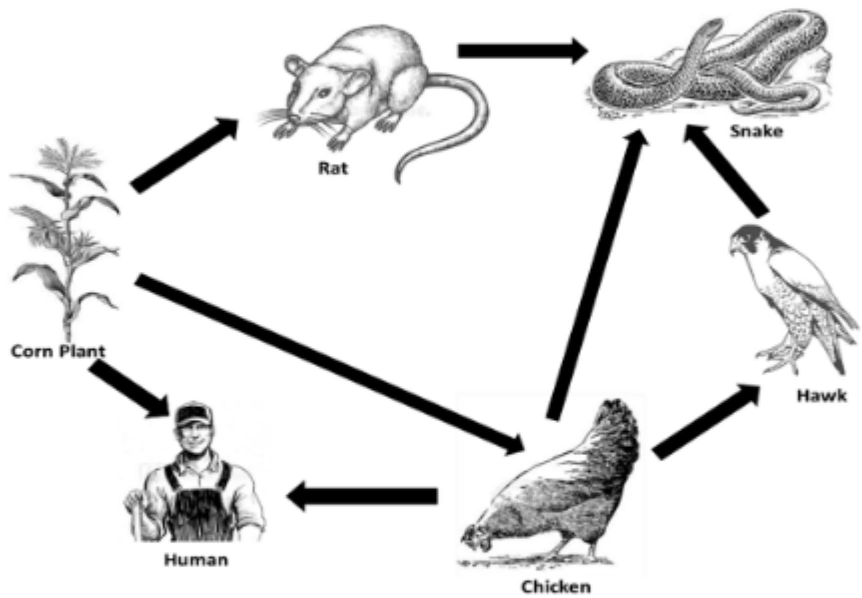
V. ENERGY FLOW IN THE ECOSYSTEM AND BIOTIC INTERACTIONS

1. Cassie visits their home garden for her ecology project. Her teacher asked her to list down the abiotic factors in that ecosystem. Which of the following should NOT be included in her list?
   A. amount of sunlight　　　C. pH of the ground soil
   B. butterflies and bees　　　D. temperature
2. What is TRUE about organisms at the highest trophic level in an energy pyramid?
   A. They are producers.
   B. They are first order consumers.
   C. The least amount of energy is transferred to them.
   D. The greatest amount of energy is transferred to them.
3. If there are 8,000 kilocalories of energy in the first trophic level, how many kilocalories are available to organisms in the second trophic level?
   A. 0.8 kcal　　　C. 80 kcal
   B. 8 kcal　　　D. 800 kcal
4. Which of the following BEST describes a biome?
   A. All the areas on Earth where life exists.
   B. Atmospheric conditions in an area for specific period of time.
   C. A region characterized by specific climate and community of organisms.
   D. An area where the animal population interacts with its abiotic environment.
5. During harvest time, abundant food supply is accompanied by the increase in the number of field mice that prey on rice grains. Snakes that prey on field mice also will increase in number. What could be the possible outcomes if the farmers get rid of the snakes?

I. The snake population will increase.
II. The food supply will decrease.
III. The field mice population will double.
IV. The field mice population will control the snake of population.

   A. I only　　　C. I and III only
   B. II and III only　　　D. II and IV only

Use the diagram of the food web below to answer items 6-10.



6. From the above food web, which is correct sequence of a food chain?

   A. Snake → chicken → rat
   B. Chicken → rat → corn plant
   C. corn plant → eagle → snake
   D. corn plant → chicken → hawk

7. Using the food web above, what will happen to the chicken if the corn plant dies?

   A. The chicken will feed on hawk.
   B. The chicken will eventually die.
   C. The chicken will feed on the rat.
   D. The chicken will increase in population.

8. From the food web above, which is NOT a food chain?

   A. corn plant → chicken → man
   B. corn plant → rat → snake → hawk
   C. snake → hawk → chicken → corn plant
   D. corn plant → chicken → snake → hawk

9. The herbivores in the above food web are:

   A. man and hawk.
   B. chicken and rat.
   C. snake and man.
   D. hawk and snake.

10. The primary consumers in the above food web are

    A. chicken, rat and man.
    B. chicken and snake.
    C. hawk, snake and rat.
    D. corn and man.

11. A group of different species of plants and insects living together in your home garden is called _______.

    A. a community
    B. a population
    C. a biome
    D. a habitat

12. What type of symbiotic relationship is shown in this picture where aphids are feasting on the sap of the hot pepper plant?

    A. predation
    B. amensalism
    C. parasitsm
    D. mutualism

13. How are energy and matter used in the ecosystem?

    A. Matter is used in the ecosystem; energy is not.
    B. Energy is cycled through ecosystem; matter is not.
    C. Matter is cycled through ecosystems; energy is not.
    D. Energy can be converted into matter; matter cannot be converted into energy.

14. A population is CORRECTLY defined as having which of the following characteristics?

    I. Inhabiting the same general area
    II. Individuals belonging to the same species
    III. Possessing a constant and uniform density and dispersion

    A. I and II only
    B. I and III only
    C. II and III only
    D. I, II and III

15. Which of the following descriptions about the organization of an ecosystem is CORRECT?

    A. Populations make up species, which make up communities.
    B. Species make up populations, which make up communities
    C. Species make up communities, which make up populations.
    D. Communities make up species, which make up populations.

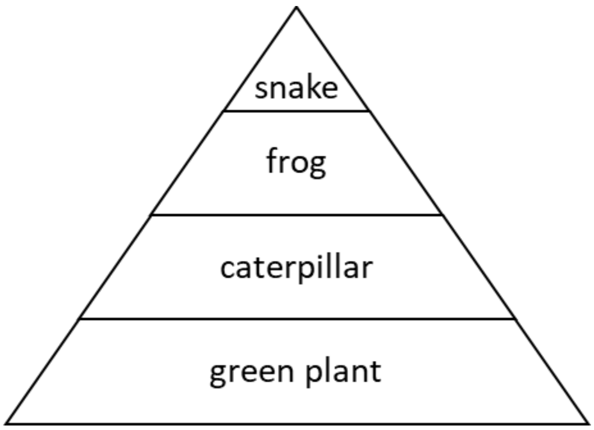
16. Which term best describes the number of different species in the biosphere or in a particular area?

    A. biodiversity
    B. ecosystem diversity
    C. genetic diversity
    D. species diversity

17. All of the following are threats to biodiversity EXCEPT:
    A. Desertification
    B. Habitat preservation
    C. Habitat fragmentation
    D. Biological magnification of toxic compounds
18. Introduced species can threaten biodiversity because they can
    A. cause desertification
    C. crowd out native species
    B. cause biological magnification
    D. reduce the amount of fertile land
19. After cultivating a piece of land in your front yard, you transplanted the pechay seedlings in a way that they are equally spaced from one another as shown in the picture on the right. What type of dispersion pattern is being exhibited by the lay out of your garden plot?

    A. random
    C. clumped
    B. uniform
    D. aggregated
19. Which of the following correctly describes the relationship between a fern attached to a tree?
    A. The fern is benefitted while the tree is harmed.
    B. The fern is harmed while the tree is benefitted.
    C. The fern is benefitted while the tree is unaffected.
    D. The fern and the tree both benefit from the relationship.

20. Aphids have infested the roses in your garden. You know that aphids are a pest insect that can damage your roses, and there are lots of them. Which of the following methods of control would be the SAFEST for the environment?
    A. Spray them with alcohol them.
    B. Spray them with oil to suffocate them.
    C. Spray them with a pesticide to kill them.
    D. Spray them with water with dish soap to try to knock them off the roses.
21. The diagram below represents a food pyramid in home garden ecosystem.



The best explanation for the decrease in the amount of energy transferred to each succeeding level is that much of the energy is ________________

    A. used in photosynthesis.
    C. within inorganic materials.
    B. consumed by predators.
    D. converted and released as heat.

22. If you count 60 ants from your home garden measuring 3 square meters, what is the population density of the ants?
    A. 180 ants per square meter
    B. 20 ants per square meter
    C. 5 ants per square meter
    D. 4 ants per square meter
23. An organism's particular role in its habitat, or when and how it survives, is its
    A. niche
    B. ecosystem
    C. limiting factors
    D. carrying capacity.
25. The tree frog uses plants or trees for protection from the rain. The frog is protected from the rain and the tree is neither helped nor harmed. What form of symbiosis is this?
    A. Mutualism
    B. Parasitism
    C. Commensalism
    D. Symbiosis

END OF EXAM

Appendix J: Curriculum Guide in Earth and Life Science (Life Science Part)

K to 12 BASIC EDUCATION CURRICULUM
SENIOR HIGH SCHOOL – CORE SUBJECT

Grade: 11/12
Core Subject Title: Earth and Life Science

Semester: 1
No. of Hours: 80 hours (20 Weeks)
Pre-requisite:

Core Subject Description: This learning area is designed to provide a general background for the understanding of Earth Science and Biology. It presents the history of the Earth through geologic time. It discusses the Earth's structure, composition, and processes. Issues, concerns, and problems pertaining to natural hazards are also included. It also deals with the basic principles and processes in the study of biology. It covers life processes and interactions at the cellular, organism, population, and ecosystem levels.

CONTENT	CONTENT STANDARD	PERFORMANCE STANDARD	LEARNING COMPETENCIES	CODE	SCIENCE EQUIPMENT
I. INTRODUCTION TO LIFE SCIENCE	*The learners demonstrate an understanding of:* 1. the historical development of the concept of life 2. the origin of the first life forms 3. unifying themes in the study of life	*The learners shall be able to:* value life by taking good care of all beings, humans, plants, and animals	*The learners:* 1. explain the evolving concept of life based on emerging pieces of evidence	**S11/12LT -IIa-1**	
			2. describe classic experiments that model conditions which may have enabled the first forms to evolve	**S11/12LT -IIa-2**	
			3. describe how unifying themes (e.g., structure and function, evolution, and ecosystems) in the study of life show the connections among living things and how they interact with each other and with their environment	**S11/12LT -IIa-3**	

CONTENT	CONTENT STANDARD	PERFORMANCE STANDARD	LEARNING COMPETENCIES	CODE	SCIENCE EQUIPMENT
II. BIOENERGETICS	*The learners demonstrate an understanding of:* 1. the cell as the basic unit of life 2. how photosynthetic organisms capture light energy to form sugar molecules 3. how organisms obtain and utilize energy	*The learners shall be able to:* make a poster that shows the complementary relationship of photosynthesis and cellular respiration	*The learners:* 1. explain how cells carry out functions required for life	**S11/12LT -IIbd-4**	
			2. explain how photosynthetic organisms use light energy to combine carbon dioxide and water to form energy-rich compounds	**S11/12LT -IIbd-5**	1. Beral Pipette Dropper, 1 ml. capacity 2. Bromthymol blue, 100 ml / bottle 3. Filter Paper, ordinary, 24" x 24" sheet 4. Glass Funnel, Ø 50mm (Top Inside Diameter), 75mm long Stem 5. Test Tube, Ø 16mm x 150mm long 6. Wash Bottle, plastic, 250 ml.
			3. trace the energy flow from the environment to the cells.	**S11/12LT -IIbd-6**	

CONTENT	CONTENT STANDARD	PERFORMANCE STANDARD	LEARNING COMPETENCIES	CODE	SCIENCE EQUIPMENT
			4. describe how organisms obtain and utilize energy	**S11/12LT -IIbd-7**	1. Alcohol Thermometer, -20ºC to 110ºC 2. Beaker, 250 ml., borosilicate 3. Bromthymol blue, 100 ml / bottle 4. Graduated Cylinder, 10 ml., soda lime 5. Tripod, Height: 6" 6. Litmus Paper Strips, blue, 100's/vial 7. Litmus Paper Strips, red, 100's/vial 8. Yeast, granules, active dry yeast, 100 grams / bottle
			5. recognize that organisms require energy to carry out functions required for life	**S11/12LT -IIbd-8**	
III. PERPETUATION OF LIFE	*The learners demonstrate an understanding of:* 1. plant and animal reproduction	*The learners shall be able to:* conduct a survey of products containing substances that can trigger genetic disorders such as phenylketonuria	*The learners:* 1. describe the different ways of how plants reproduce	**S11/12LT -IIej-13**	
			2. illustrate the relationships among structures of flowers, fruits, and seeds	**S11/12LT -IIej-14**	
			3. describe the different ways of how representative animals reproduce	**S11/12LT -IIej-15**	
	2. how genes work		4. explain how the information in the DNA allows the transfer of genetic information and synthesis of proteins	**S11/12LT -IIej-16**	

CONTENT	CONTENT STANDARD	PERFORMANCE STANDARD	LEARNING COMPETENCIES	CODE	SCIENCE EQUIPMENT
	3. how genetic engineering is used to produce novel products		5. describe the process of genetic engineering	**S11/12LT -IIej-17**	
			6. conduct a survey of the current uses of genetically modified organisms	**S11/12LT -IIej-18**	
			7. evaluate the benefits and risks of using GMOs	**S11/12LT -IIej-19**	
IV. HOW ANIMALS SURVIVE	*The learners demonstrate an understanding of:* 1. nutrition: getting food to cells 2. gas exchange with the environment 3. circulation: the internal transport system 4. the need for homeostasis 5. salt and water balance and waste removal 6. the immune system: defense from disease 7. how hormones govern body activities 8. the nervous system 9. the body in motion	*The learners shall be able to:* make a presentation of some diseases that are associated with the various organ systems	*The learners:* 8. explain the different metabolic processes involved in the various organ systems	**S11/12LT -IIIaj-20**	1. Alcohol Thermometer, -20ºC to 110ºC 2. Beaker, 250 ml., borosilicate 3. Beral Pipette Dropper, 1 ml. capacity 4. Graduated Cylinder, 10 ml., soda lime 5. Test Tube, Ø 16mm x 150mm long 6. Wash Bottle, plastic, 250 ml.
			9. describe the general and unique characteristics of the different organ systems in representative animals	**S11/12LT -IIIaj-21**	Dissecting Set
			10. analyze and appreciate the functional relationships of the different organ systems in ensuring animal survival	**S11/12LT -IIIaj-22**	Model, Human Torso
V. HOW PLANTS SURVIVE	*The learners demonstrate an understanding of:* 1. plant form and function 2. plant growth	*The learners shall be able to:* design a setup on propagating plants using other methods such as hydroponics and aeroponics	*The learners:* 11. describe the structure and function of the different plant organs	**S11/12LT -IVae-23**	1. Digital Microscope 2. Hand Lens, at least 5x magnification 3. Microscope, Compound

CONTENT	CONTENT STANDARD	PERFORMANCE STANDARD	LEARNING COMPETENCIES	CODE	SCIENCE EQUIPMENT
	and development				4. Petri Dish
			12. explain the different metabolic processes involved in the plant organ systems	**S11/12LT -IVae-24**	
VI. THE PROCESS OF EVOLUTION	*The learners demonstrate an understanding of:* 1. the evidence for evolution 2. the origin and extinction of species	*The learners shall be able to:* Design a poster tracing the evolutionary changes in a crop plant (e.g., rice or corn) that occurred through domestication	*The learners:* 13. describe evidence of evolution such as homology, DNA/protein sequences, plate tectonics, fossil record, embryology, and artificial selection/agriculture	**S11/12LT -IVfg-25**	
			13. explain how populations of organisms have changed and continue to change over time showing patterns of descent with modification from common ancestors to produce the organismal diversity observed today	**S11/12LT -IVfg-26**	
			14. describe how the present system of classification of organisms is based on evolutionary relationships	**S11/12LT -IVfg-27**	
VII. INTERACTION AND INTERDEPENDENCE	*The learners demonstrate an understanding of:* 1. the principles of the ecosystem 2. biotic potential and environmental resistance 3. terrestrial and aquatic ecosystems 4. how human activities affect the natural ecosystem	*The learners shall be able to:* prepare an action plan containing mitigation measures to address current environmental concerns and challenges in the community	*The learners:* 15. describe the principles of the ecosystem	**S11/12LT -IVhj-28**	
			16. categorize the different biotic potential and environmental resistance (e.g., diseases, availability of food, and predators) that affect population explosion	**S11/12LT -IVhj-29**	
			17. describe how the different terrestrial and aquatic ecosystems are interlinked with one another	**S11/12LT -IVhj-30**	

K to 12 BASIC EDUCATION CURRICULUM
SENIOR HIGH SCHOOL – CORE SUBJECT

Code Book Legend

Sample: S11/12ES-Ia-e-1

LEGEND		SAMPLE	
First Entry	Learning Area and Strand/ Subject or Specialization	Science	**S11/12**
	Grade Level	Grade 11/12	
Uppercase Letter/s	Domain/Content/ Component/ Topic	Earth Science	**ES**
			-
Roman Numeral **Zero if no specific quarter*	Quarter	First Quarter	**I**
Lowercase Letter/s **Put a hyphen (-) in between letters to indicate more than a specific week*	Week	Weeks one to five	**a-e**
			-
Arabic Number	Competency	State the different hypotheses explaining the origin of the universe	**1**

DOMAIN/ COMPONENT	CODE
Earth Science	ES
Life Science	LT

References:

Alberts, Bruce et. al. *Molecular biology of the cell. (5th ed.)*. New York: Garland Publishing, 2007.

Appendix K: Sample Daily Lesson Log in Life Science

LESSON EXEMPLAR	School	PANTAY INTEGRATED HIGH SCHOOL	Grade Level	Grade XI
	Teacher	BAYANI T. VICENCIO	Learning Area	EAL Science
	Teaching Date		Quarter	First Quarter
	Teaching Time		No. of Days	2

	Garden-based Learning
I. Objectives	At the end of the lesson, students should be able to: a. discuss the characteristics of living things that distinguish it from non-living; b. describe the structures and functions of cell organelles; and c. conduct garden-based activities to investigate characteristics of living things
A. Content Standards	Students demonstrate an understanding of the unifying themes in the study of life.
B. Performance Standards	Students should be able to value life by taking good care of all beings, humans, plants, and animals.
C. Most Essential Learning Competencies (MELCs)	Explain the evolving concepts of life based on emerging pieces of evidence.
II. Content	**CHARACTERISTICS OF LIVING THINGS**
III. Learning Resources	
A. References	
IV. Procedure	
A. Introduction	
A.1 What I need to know?	**Communicating Learning Objectives:** • The learners will do the walkthrough of the lesson expectations. • In this part, the content of the lesson will also be presented. • Learning objectives will also be introduced to guide the learners on the learning targets founded on KSAV principles.
A.2. What do I know?	**Learning Task 1: *Test Yourself*** The learners will answer a 15-item multiple choice pretest questions.
B. Development	
B.1 What's in?	**Learning Task 2: *Find my Perfect Match*** The learners will perform Learning Task 2 wherein they will match properly the name of the scientist with the experiment they have conducted and then classify them as either supporters of biogenesis or abiogenesis theory.
B.2 What's new?	**Learning Task 3: *What an Amazing Life!*** In this activity, students will think of the things that a living organism can do. Draw a living organism at the center of the simple web mind map. Then write the characteristics of life on the circles on the side (one each box).

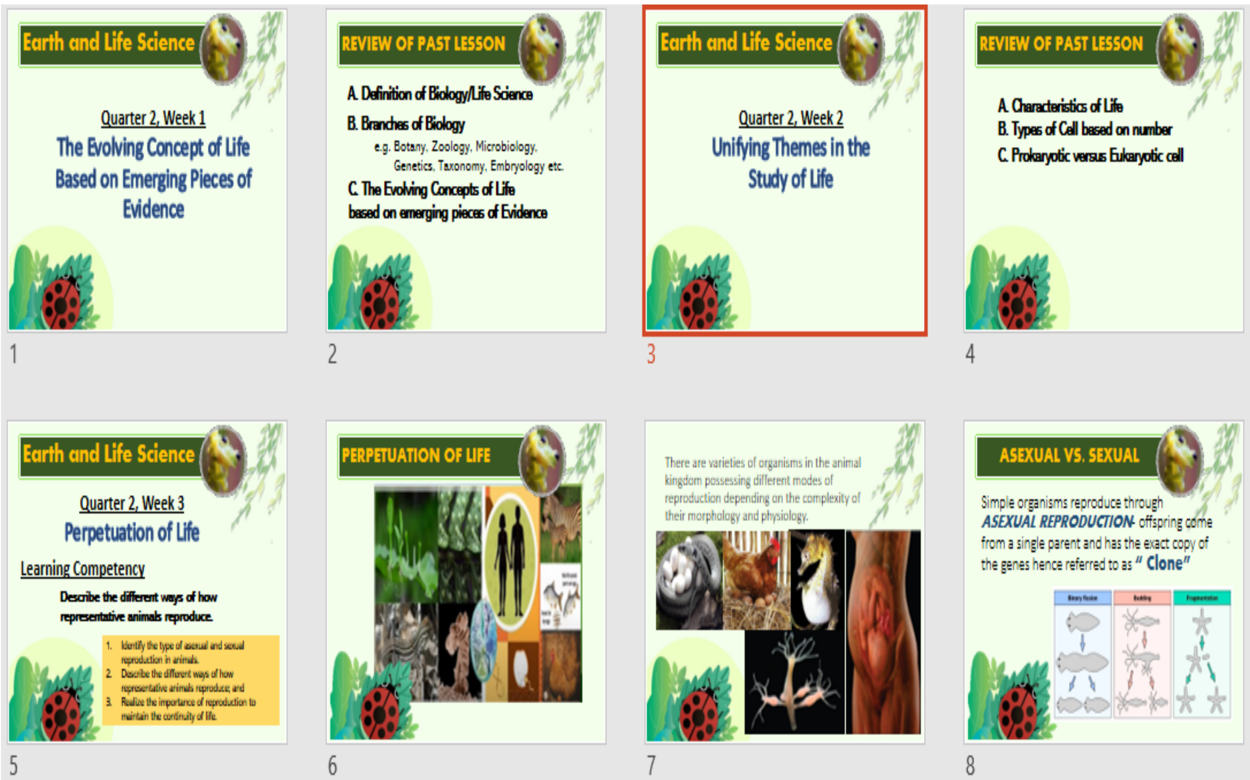
<table>
<tr><td>B.3 What is it?</td><td>Learning Task 4: A Closer Look

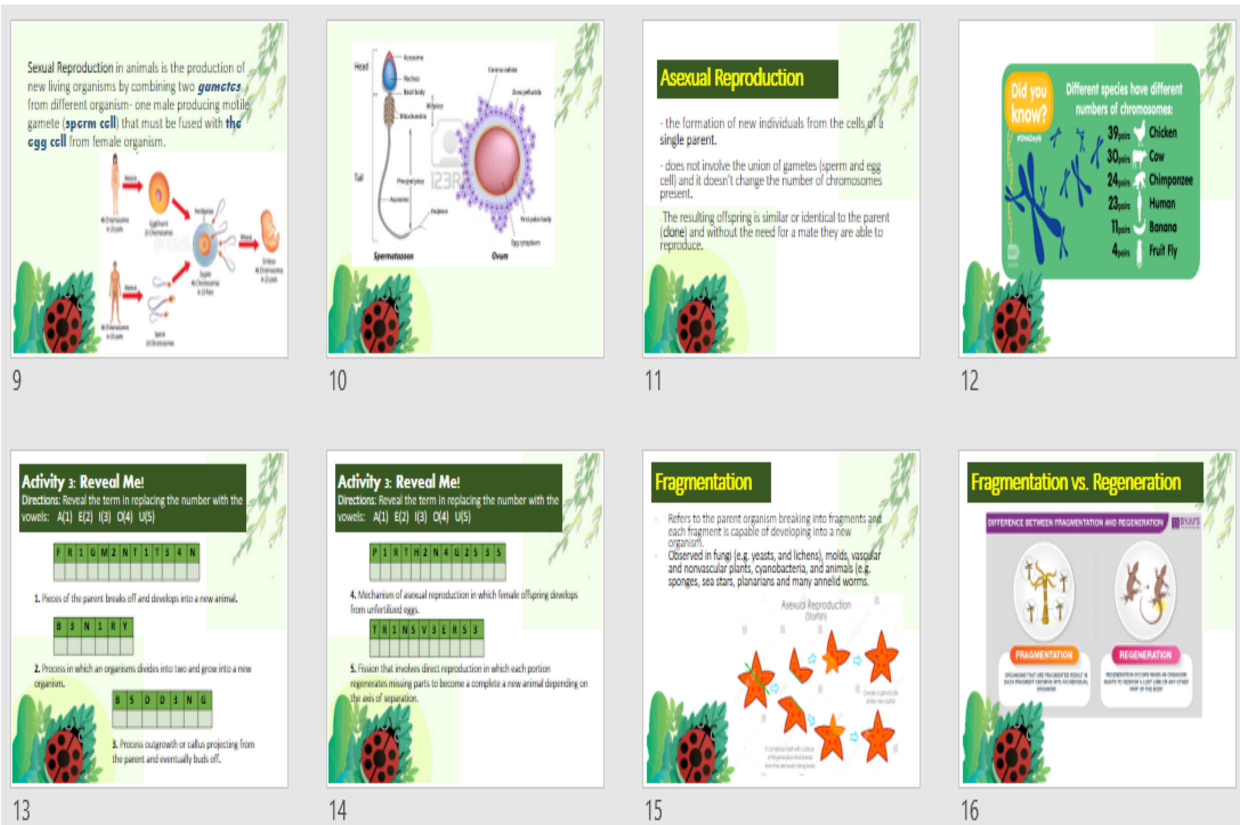
Using the SLM module on page 45-47, the learners will read the discussion on the following topics:
A. 7 Basic Characteristics of Life
B. Tour of the cell</td></tr>
<tr><td>C. Engagement</td><td></td></tr>
<tr><td>C.1 What's more?</td><td>Learning Task 5: Garden-based Activity 1

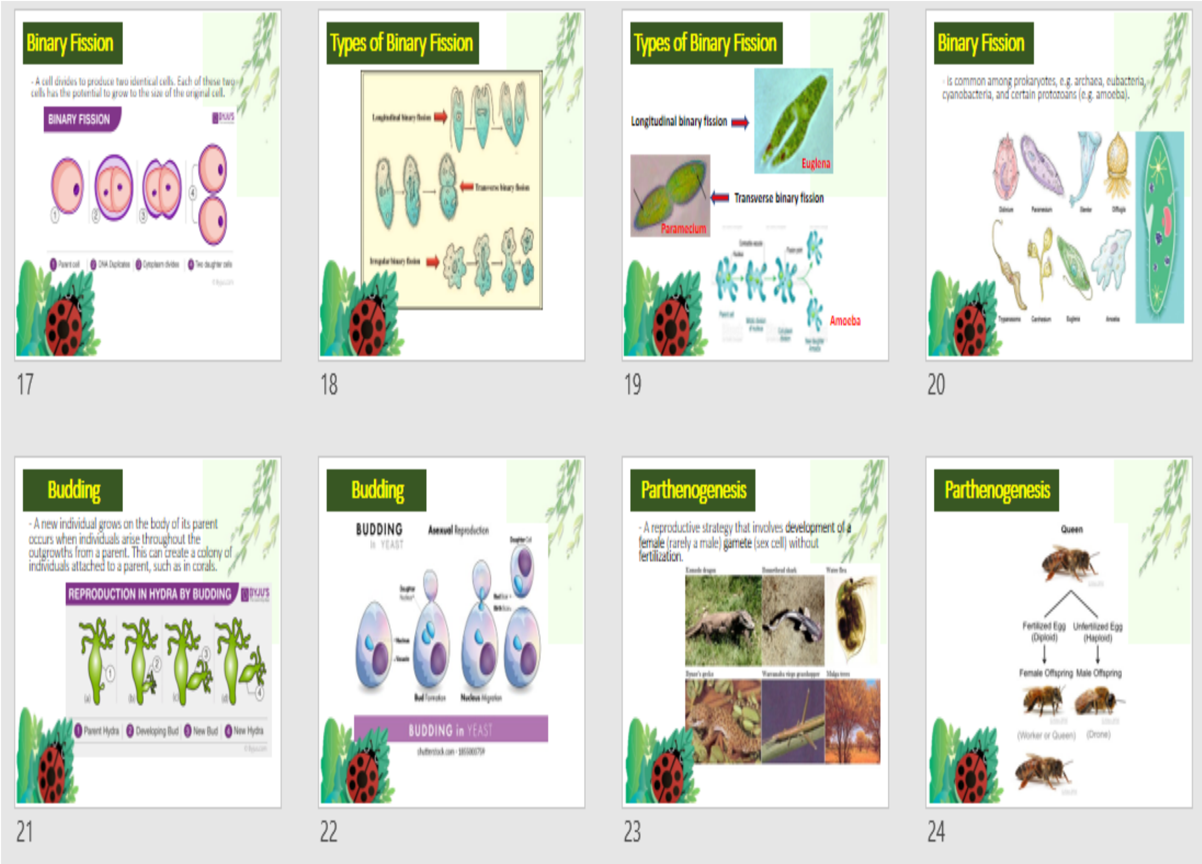
Students will perform the Garden-based Activity entitled "Crazy Little called Life".</td></tr>
<tr><td>C.1 What can I do?</td><td>Learning Task 6: Garden-based Activity 2

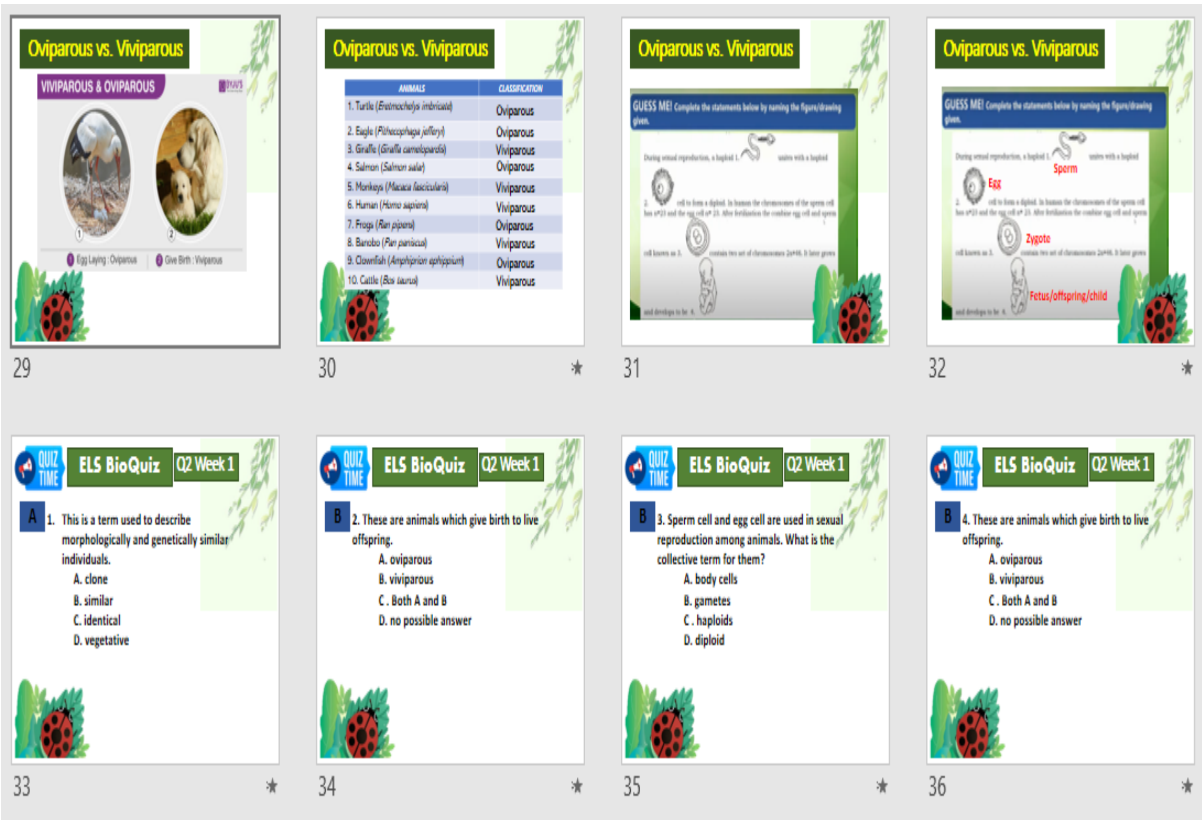
Students will perform the Garden-based activity entitled "Investigating Plant Cells"</td></tr>
<tr><td>D. Assimilation</td><td></td></tr>
<tr><td>D.1 What have I learned?</td><td>Learning Task 9: Concept Mapping
In order to help learners to organize, connect and synthesize what they have learned from the module, they will be asked to complete the concept map by supplying the correct word/s from the list.
Learning Task 10: Completing the L-I-N-K Table
Ask the learners to complete the table by answering the last two columns of the table below:
<table><tr><th>List everything you know</th><th>Inquire about what you want to know</th><th>Now we are taking down notes</th><th>What do you know now?</th></tr><tr><td></td><td></td><td></td><td></td></tr></table></td></tr>
<tr><td>D.2 What can I do? (Assessment)</td><td>Learning Task 8: Size Up
Students will answer a 15-item multiple choice post-test questions.</td></tr>
<tr><td>D.3 Additional Activities/Enrichment Activities</td><td>Learning Task: Short-essay Questions
1. How is genetic engineering different from selective breeding?
2. Discuss the advantages and disadvantages of genetic engineering.
3. Describe how genetic engineering can benefit the agricultural sector of our country.</td></tr>
<tr><td>E. Reflection</td><td>In their journal notebook or portfolio, the learners will write their answers on the following questions:
1. Which of the topics interest you the most? Why?
2. Which of the topics interest you the least? Why?
3. Did the activities help you understand the topic (Y/N)? Explain your answer.
4. Did you see the significance/ connection of the topic in your life?</td></tr>
</table>

Appendix L: Sample Slide Deck Presentation






Binary Fission
- A cell divides to produce two identical cells. Each of these two cells has the potential to grow to the size of the original cell.
BINARY FISSION
17
Types of Binary Fission
18
Types of Binary Fission
Longitudinal binary fission
Euglena
Transverse binary fission
Paramecium
Amoeba
19
Binary Fission
- is common among prokaryotes, e.g. archaea, eubacteria, cyanobacteria, and certain protozoans (e.g. amoeba).
20
Budding
- A new individual grows on the body of its parent occurs when individuals arise throughout the outgrowths from a parent. This can create a colony of individuals attached to a parent, such as in corals.
REPRODUCTION IN HYDRA BY BUDDING
21
Budding
BUDDING
Asexual Reproduction
BUDDING in YEAST
22
Parthenogenesis
- A reproductive strategy that involves development of a female (rarely a male) gamete (sex cell) without fertilization.
23
Parthenogenesis
Queen
Fertilized Egg (Diploid)
Unfertilized Egg (Haploid)
Female Offspring
Male Offspring
(Worker or Queen)
(Drone)
24


Oviparous vs. Viviparous
VIVIPAROUS & OVIPAROUS
Egg Laying : Oviparous
Give Birth : Viviparous
29
Oviparous vs. Viviparous
ANIMALS
CLASSIFICATION
1. Turtle (Eretmochelys imbricata) Oviparous
2. Eagle (Pithecophaga jefferyi) Oviparous
3. Giraffe (Giraffa camelopardis) Viviparous
4. Salmon (Salmon salar) Oviparous
5. Monkeys (Macaca fascicularis) Viviparous
6. Human (Homo sapiens) Viviparous
7. Frogs (Ran pipens) Oviparous
8. Banobo (Pan paniscus) Viviparous
9. Clownfish (Amphiprion ephippium) Oviparous
10. Cattle (Bos taurus) Viviparous
30
Oviparous vs. Viviparous
GUESS ME! Complete the statements below by naming the figure/drawing given.
31
Oviparous vs. Viviparous
GUESS ME! Complete the statements below by naming the figure/drawing given.
Sperm
Egg
Zygote
Fetus/offspring/child
32
QUIZ TIME
ELS BioQuiz
Q2 Week 1
A
1. This is a term used to describe morphologically and genetically similar individuals.
A. clone
B. similar
C. identical
D. vegetative
33
QUIZ TIME
ELS BioQuiz
Q2 Week 1
B
2. These are animals which give birth to live offspring.
A. oviparous
B. viviparous
C . Both A and B
D. no possible answer
34
QUIZ TIME
ELS BioQuiz
Q2 Week 1
B
3. Sperm cell and egg cell are used in sexual reproduction among animals. What is the collective term for them?
A. body cells
B. gametes
C . haploids
D. diploid
35
QUIZ TIME
ELS BioQuiz
Q2 Week 1
B
4. These are animals which give birth to live offspring.
A. oviparous
B. viviparous
C . Both A and B
D. no possible answer
36

Appendix M: Reliability Test for Learning Engagement Survey Questionnaire

Reliability on the Cognitive Engagement

Reliability Statistics	
Cronbach's Alpha	N of Items
.912	13

Item-Total Statistics				
	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Q3	38.64	31.073	.608	.906
Q8	38.97	30.376	.625	.905
Q11	38.99	28.971	.793	.898
Q13	38.83	29.130	.771	.899
Q17	38.91	29.819	.678	.903
Q20	38.94	29.533	.639	.905
Q21	39.06	33.591	.196	.920
Q26	38.87	30.490	.637	.905
Q29	38.89	30.219	.657	.904
Q32	38.83	29.014	.711	.901
Q33	38.84	31.352	.471	.911
Q35	39.06	28.895	.680	.903
Q37	38.89	29.958	.765	.900

Reliability on the Affective Engagement

Reliability Statistics	
Cronbach's Alpha	N of Items
.819	14

Item-Total Statistics				
	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Q1	39.73	31.563	.266	.819
Q6	40.09	32.717	.058	.834
Q9	40.00	31.304	.363	.814
Q10	39.90	30.265	.443	.809
Q12	39.79	29.852	.474	.807
Q15	40.10	29.570	.570	.801
Q18	39.91	28.282	.559	.799
Q23	39.57	28.422	.556	.800
Q24	40.69	27.001	.500	.806
Q25	40.33	28.456	.545	.800
Q31	40.51	28.398	.448	.809
Q36	40.43	29.147	.432	.809
Q38	40.20	28.858	.572	.799
Q41	39.80	28.974	.526	.802

Reliability on the Behavioral Engagement

Reliability Statistics	
Cronbach's Alpha	N of Items
.827	14

Item-Total Statistics				
	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Q2	42.84	19.468	.249	.828
Q4	42.79	18.664	.409	.819
Q5	42.97	17.564	.568	.808
Q7	43.00	17.971	.584	.808
Q14	42.91	19.732	.178	.833
Q16	43.07	17.951	.500	.813
Q19	42.91	19.268	.262	.828
Q22	42.77	17.860	.597	.807
Q27	43.01	17.927	.506	.812
Q28	42.96	17.984	.562	.809
Q30	42.89	18.393	.479	.815
Q34	43.10	16.468	.688	.797
Q39	43.14	17.255	.514	.812
Q40	43.53	18.195	.326	.828

Appendix N: Reliability Test for Life Science Achievement Test

Reliability Statistics

Kruger-Richardson-20	Kruger-Richardson-20 Based on Standardized Items	N of Items
.828	.822	100

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Item1	62.3750	113.369	-.052	.	.830
Item2	62.4250	108.866	.547	.	.822
Item3	62.5000	109.436	.397	.	.824
Item4	62.4250	110.661	.307	.	.826
Item5	62.3000	112.574	.157	.	.828
Item6	62.6250	110.035	.282	.	.825
Item7	62.3500	111.054	.356	.	.826
Item8	62.5000	112.103	.094	.	.828
Item9	62.5000	108.359	.521	.	.822
Item10	62.7000	108.985	.372	.	.824
Item11	62.4250	112.969	.004	.	.829
Item12	62.6000	109.118	.382	.	.824
Item13	62.5750	113.584	-.068	.	.831
Item14	62.4750	110.256	.318	.	.825
Item15	62.3000	113.395	-.087	.	.829
Item16	62.5750	109.430	.359	.	.824
Item17	62.6500	107.926	.487	.	.822
Item18	62.8500	112.797	.007	.	.830
Item19	62.7500	109.885	.282	.	.825
Item20	62.4000	112.041	.137	.	.828
Item21	63.0500	114.562	-.178	.	.832
Item22	62.6250	113.574	-.066	.	.831
Item23	62.8500	108.644	.406	.	.823
Item24	62.6000	110.451	.246	.	.826
Item25	62.7250	107.743	.491	.	.822
Item26	62.6250	108.138	.473	.	.822
Item27	62.3000	112.369	.219	.	.827
Item28	62.7250	110.256	.247	.	.826
Item29	62.7500	108.962	.370	.	.824
Item30	62.3250	112.738	.073	.	.828

Item31	62.6000	112.041	.086	.	.829
Item32	62.8250	112.148	.068	.	.829
Item33	62.8000	111.446	.134	.	.828
Item34	62.7500	105.013	.758	.	.817
Item35	62.5500	111.331	.167	.	.827
Item36	63.0250	109.461	.379	.	.824
Item37	62.8750	115.240	-.221	.	.834
Item38	62.7750	110.589	.214	.	.827
Item39	63.0250	110.487	.266	.	.826
Item40	62.4750	113.538	-.067	.	.831
Item41	62.5000	115.179	-.246	.	.833
Item42	62.9500	109.895	.302	.	.825
Item43	62.8000	115.754	-.265	.	.835
item44	62.5750	109.481	.353	.	.824
Item45	62.7500	111.269	.150	.	.828
item46	62.7500	108.859	.380	.	.824
Item47	62.5000	110.821	.239	.	.826
Item48	62.6250	108.651	.421	.	.823
Item49	62.7750	115.102	-.205	.	.834
Item50	62.8750	114.317	-.135	.	.832
Item51	62.7500	108.756	.390	.	.823
Item52	62.3500	113.003	.009	.	.829
Item53	62.7250	112.256	.058	.	.829
Item54	62.7000	109.651	.308	.	.825
Item55	62.3750	113.215	-.028	.	.829
Item56	62.7500	109.936	.277	.	.825
item57	62.7250	107.640	.501	.	.821
Item58	62.4250	110.866	.280	.	.826
Item59	62.8250	105.481	.714	.	.818
Item60	62.6250	110.548	.231	.	.826
Item61	62.5000	112.769	.020	.	.829
Item62	63.0500	110.356	.292	.	.825
Item63	62.6750	108.225	.451	.	.822
Item64	62.6000	110.246	.267	.	.826
Item65	62.7500	107.577	.505	.	.821
item66	62.5750	111.174	.178	.	.827
item67	62.7750	114.179	-.121	.	.832
Item68	62.5250	112.410	.057	.	.829
Item69	62.4750	115.692	-.313	.	.834
Item70	62.7250	111.281	.150	.	.828
Item71	62.7500	106.295	.631	.	.819
Item72	62.4250	113.892	-.116	.	.831
Item73	62.8000	108.779	.388	.	.823

Item74	62.7750	114.384	-.140	.	.833
Item75	62.7750	109.461	.322	.	.825
Item76	62.3500	111.874	.209	.	.827
Item77	62.5500	110.100	.297	.	.825
Item78	62.8250	107.379	.526	.	.821
Item79	62.7500	112.449	.039	.	.830
Item80	62.6500	112.438	.043	.	.829
Item81	62.4750	111.640	.155	.	.827
Item82	62.7500	109.013	.365	.	.824
item83	62.6750	108.892	.385	.	.824
Item84	62.5000	112.359	.066	.	.829
item85	62.5000	109.795	.356	.	.825
item86	62.4500	111.690	.159	.	.827
Item87	62.5500	113.279	-.037	.	.830
Item88	62.9500	110.408	.250	.	.826
Item89	62.9000	114.605	-.164	.	.833
Item90	62.7000	113.549	-.063	.	.831
Item91	62.9000	112.503	.037	.	.830
Item92	62.7500	106.449	.615	.	.819
Item93	62.8750	112.420	.044	.	.829
Item94	62.5000	113.077	-.014	.	.830
Item95	62.8500	106.797	.588	.	.820
Item96	62.8000	115.241	-.218	.	.834
Item97	62.5500	113.536	-.064	.	.831
Item98	62.4250	112.097	.118	.	.828
Item99	62.4500	111.228	.216	.	.827
Item100	62.4500	111.074	.235	.	.826

Appendix O: Reliability Test for Questionnaire on Students' Perception Toward GBL

Reliability Statistics

Kruger-Richardson-20	Kruger-Richardson-20 Based on Standardized Items	N of Items
.898	.879	20

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
PTGBLS1	70.1500	23.413	.767	.	.887
PTGBLS2	70.1750	23.276	.775	.	.886
PTGBLS3	70.0750	25.251	.378	.	.897
PTGBLS4	70.4250	22.763	.655	.	.890
PTGBLS5	70.2750	22.871	.800	.	.885
PTGBLS6	70.1750	23.789	.650	.	.890
PTGBLS7	70.4750	23.999	.532	.	.894
PTGBLS8	70.0250	26.589	.046	.	.904
PTGBLS9	70.2250	23.461	.691	.	.889
PTGBLS10	70.0250	27.615	-.246	.	.909
PTGBLS11	70.4000	23.169	.705	.	.888
PTGBLS12	70.0250	27.615	-.246	.	.909
PTGBLS13	70.4250	22.917	.762	.	.886
PTGBLS14	70.3000	22.882	.787	.	.885
PTGBLS15	70.0500	25.023	.472	.	.895
PTGBLS16	70.0250	26.897	-.042	.	.906
PTGBLS17	70.3750	22.753	.798	.	.885
PTGBLS18	70.0500	24.715	.561	.	.893
PTGBLS19	70.0500	24.767	.546	.	.893
PTGBLS20	70.3750	23.676	.595	.	.892

Appendix P. Students' Level of Mastery Across All Items in the LSAT Based on Item Analysis

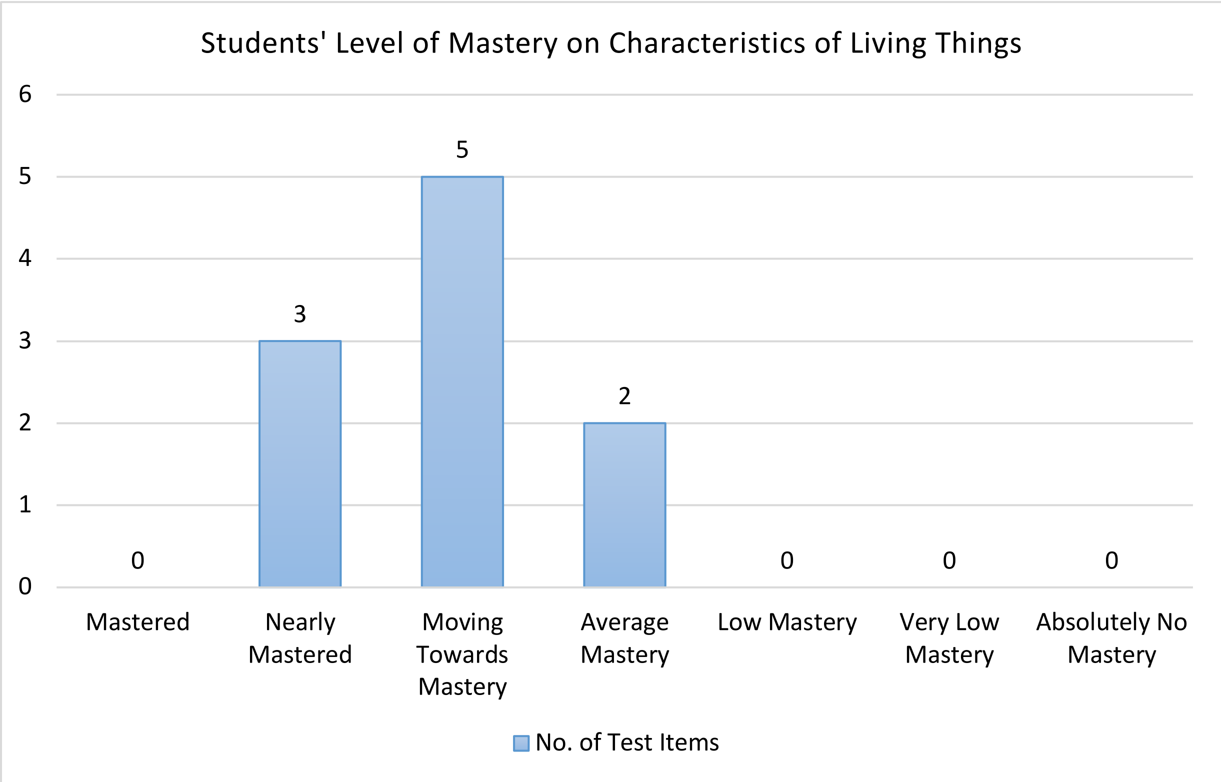
Level of Mastery	Topic I			Topic II			Topic III			Topic IV			Topic IV		
	F	%	Item No	f	%	Item No	f	%	Item No.	f	%	Item No.	f	%	Item No.
Mastered (M) (96-100)	0	***0***		0	***0***		0	***0***		1	***4***	14	0	***0***	
Closely Approaching Mastery (CAM) (86-95)	3	***30***	1,4,8	1	***4***	16	1	***6.7***	10	1	***4***	25	8	***32***	1,6,7,8, 9,10,16, 19
Moving towards mastery (MTM) (66-85)	5	***50***	2,3,5, 7,9	10	***40***	1,2,4, 10,11, 14, 20.22, 23,25	8	***53.3***	1,3,4,5,6, 9,11,12	15	***60***	1,2,5,6 ,7,8,9, 11,13, 15,16, 17,18, 21,23	13	***52***	2,3,4,5, 12,13, 14,15, 17,18, 21,23, 25
Average mastery (AM) (35-65)	2	***20***	6,10	14	***56***	3,5,6,7,8, 9,12, 13, 15,17, 18,19,21, 24	6	***40.0***	2,7,8,13,1 4,15	8	***32***	3,4,10, 12,19, 20,22, 24	4	***16***	11,20, 22,24
Low mastery (LM) (16-34)	0	***0***		0	***0***		0	***0***		0	***0***		0	***0***	
Very low mastery (VLM) (5-15)	0	***0***		0	***0***		0	***0***		0	***0***		0	***0***	
Absolutely no mastery (ANM) (0-4)	0	***0***		0	***0***		0	***0***		0	***0***		0	***0***	
TOTAL	**10**	***100***	**10**	**25**	***100***	**25**	**15**	***100***	**15**	**25**	***100***	**15**	**25**	***100***	**25**

Topic I- Characteristics of living things; Topic II- Photosynthesis; Topic III- Plant reproduction; Topic IV- Plant form and function; Topic V- Interaction and interdependence

Appendix Q: Item Analysis of Characteristics of Living Things

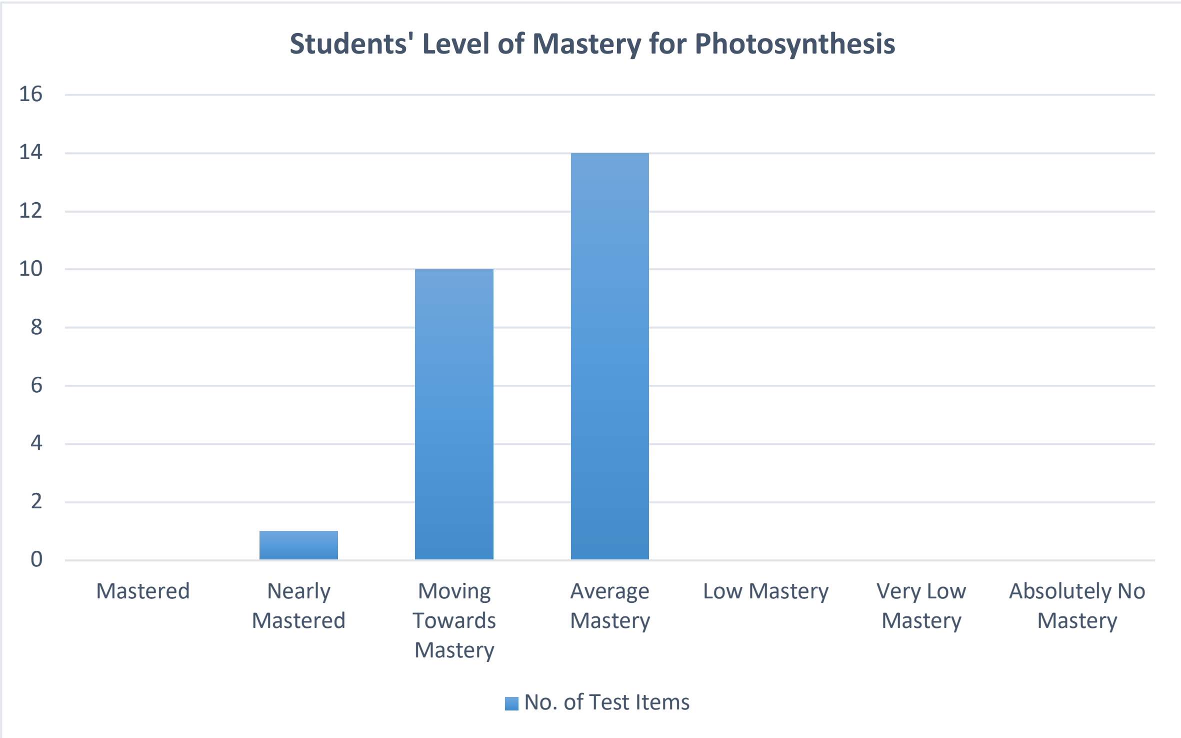
Test Item	No. Of Correct Answers	% of Correct Response	Mastery Level
1	62	88.57	Nearly Mastered
2	51	72.86	Moving Towards Mastery
3	54	77.14	Moving Towards Mastery
4	61	87.14	Nearly Mastered
5	56	80.00	Moving Towards Mastery
6	39	55.71	Average Mastery
7	56	80.00	Moving Towards Mastery
8	64	91.43	Nearly Mastered
9	53	75.71	Moving Towards Mastery
10	45	64.29	Average Mastery
	SUM	**541.00**	
	MEAN	**7.73**	
	STD	**7.72**	

Percentage	Descriptive Equivalent	No. of Test Items
96-100	Mastered	0
86-95	Nearly Mastered	3
66-85	Moving Towards Mastery	5
35-65	Average Mastery	2
16-34	Low Mastery	0
5-15	Very Low Mastery	0
0-4	Absolutely No Mastery	0


Students' Level of Mastery on Characteristics of Living Things
6
5
4
3
2
1
0
0
3
5
2
0
0
0
Mastered
Nearly Mastered
Moving Towards Mastery
Average Mastery
Low Mastery
Very Low Mastery
Absolutely No Mastery
No. of Test Items

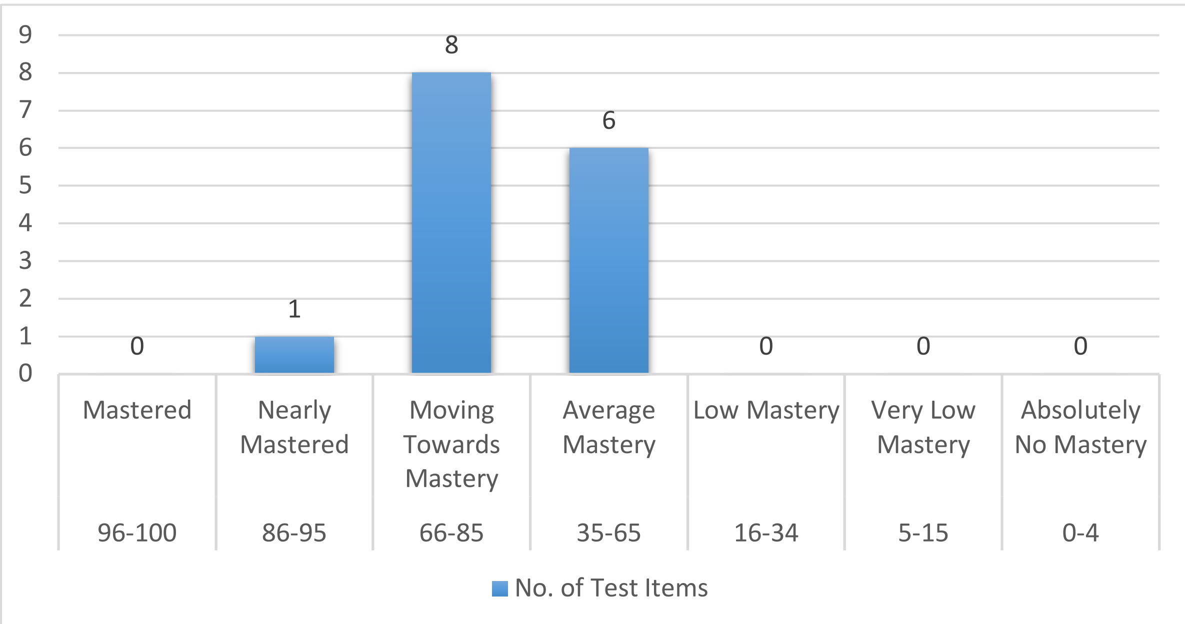
Appendix R: Item Analysis of Photosynthesis

Test Item	No. Of Correct Answers	% of Correct Response	Level of Mastery
1	47	67.14	Moving Towards Mastery
2	47	67.14	Moving Towards Mastery
3	31	44.29	Average Mastery
4	52	74.29	Moving Towards Mastery
5	45	64.29	Average Mastery
6	44	62.86	Average Mastery
7	43	61.43	Average Mastery
8	38	54.29	Average Mastery
9	40	57.14	Average Mastery
10	52	74.29	Moving Towards Mastery
11	46	65.71	Moving Towards Mastery
12	41	58.57	Average Mastery
13	40	57.14	Average Mastery
14	52	74.29	Moving Towards Mastery
15	43	61.43	Average Mastery
16	64	91.43	Nearly Mastered
17	36	51.43	Average Mastery
18	33	47.14	Average Mastery
19	47	67.14	Average Mastery
20	55	78.57	Moving Towards Mastery
21	36	51.43	Average Mastery
22	54	77.14	Moving Towards Mastery
23	59	84.29	Moving Towards Mastery
24	44	62.86	Average Mastery
25	51	72.86	Moving Towards Mastery
	SUM	**1140.00**	
	MEAN	**16.29**	
	STD	**8.04**	
	MPS	**65.14285714**	


Students' Level of Mastery for Photosynthesis
16
14
12
10
8
6
4
2
0
Mastered
Nearly Mastered
Moving Towards Mastery
Average Mastery
Low Mastery
Very Low Mastery
Absolutely No Mastery
No. of Test Items

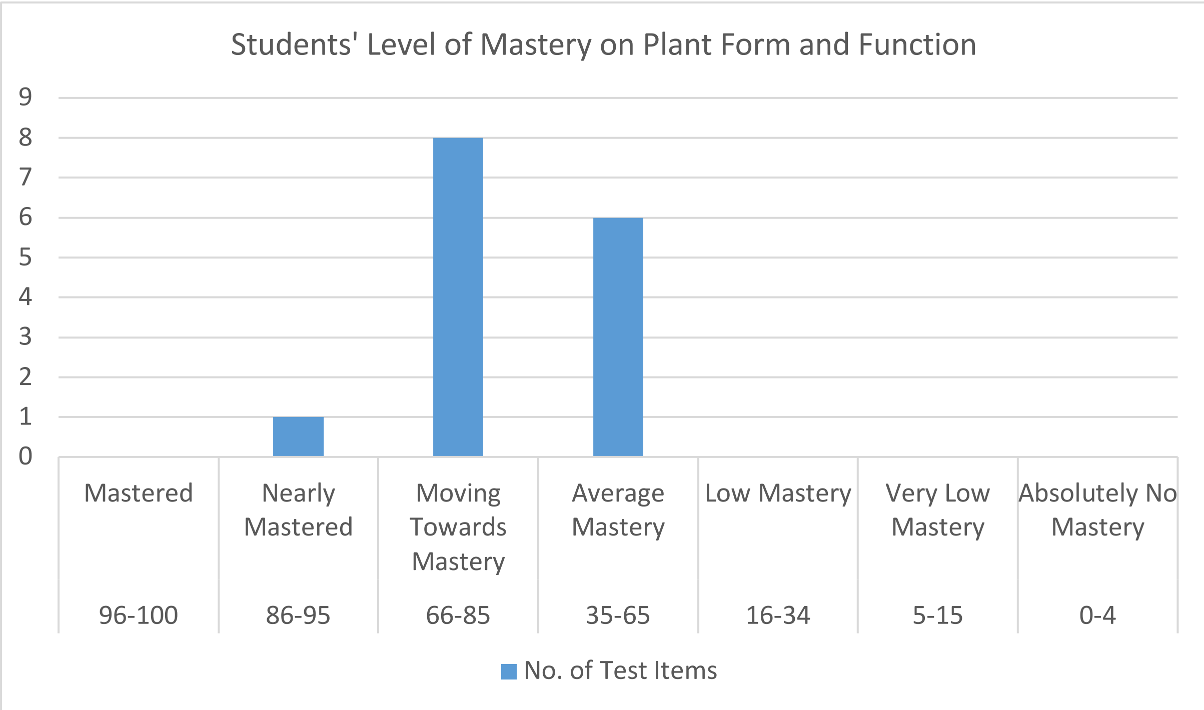
Appendix S: Item Analysis of Plant Reproduction

Test Item Number	No. Of Students Who Answered Correctly	% of Correct Response	Remarks
1	48	68.57	Moving Towards Mastery
2	40	57.14	Average Mastery
3	59	84.29	Moving Towards Mastery
4	51	72.86	Moving Towards Mastery
5	50	71.43	Moving Towards Mastery
6	55	78.57	Moving Towards Mastery
7	45	64.29	Average Mastery
8	25	35.71	Average Mastery
9	47	67.14	Moving Towards Mastery
10	61	87.14	Nearly Mastered
11	57	81.43	Moving Towards Mastery
12	47	67.14	Moving Towards Mastery
13	39	55.71	Average Mastery
14	43	61.43	Average Mastery
15	39	55.71	Average Mastery
	SUM	706.00	
	MEAN	10.09	
	STD	9.30	
	MPS	67.23809524	



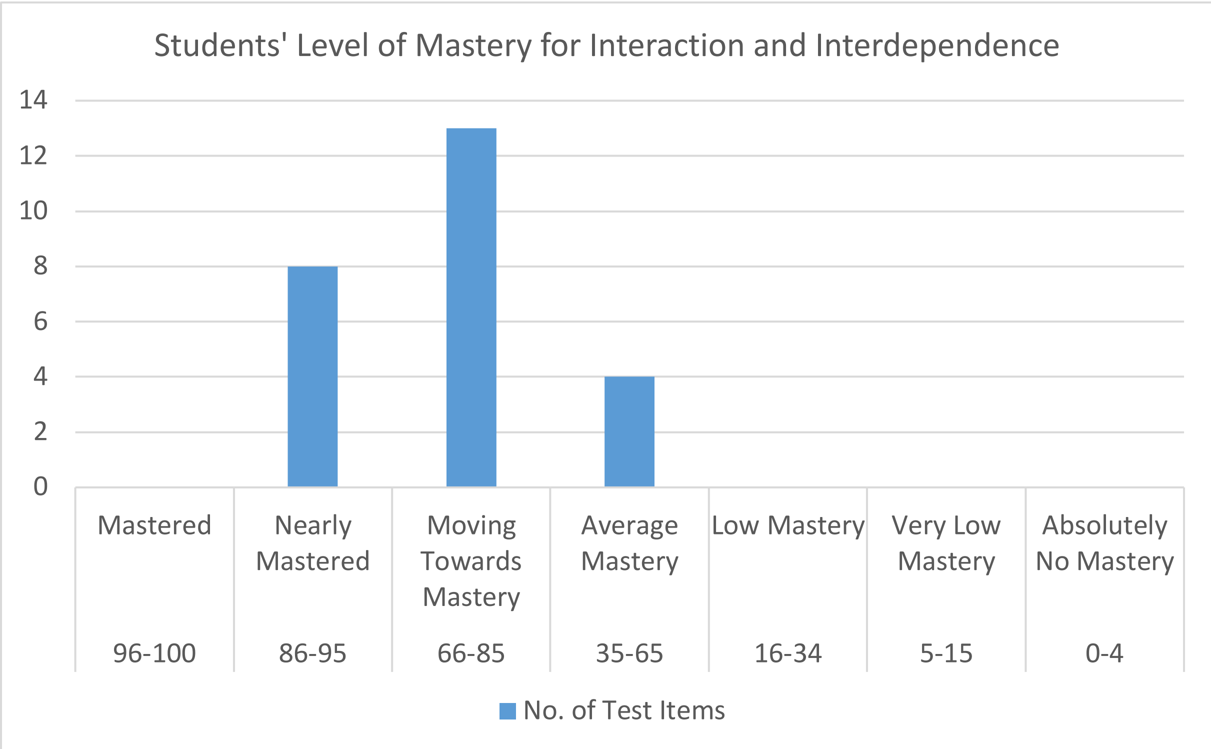
Appendix T: Item Analysis of Plant Form and Function

Test Item	No. Of Correct Answers	% of Correct Response	Remarks
1	52	74.29	Moving Towards Mastery
2	53	75.71	Moving Towards Mastery
3	34	48.57	Low Mastery
4	45	64.29	Average Mastery
5	56	80.00	Moving Towards Mastery
6	50	71.43	Moving Towards Mastery
7	54	77.14	Moving Towards Mastery
8	52	74.29	Moving Towards Mastery
9	50	71.43	Moving Towards Mastery
10	42	60.00	Average Mastery
11	46	65.71	Moving Towards Mastery
12	37	52.86	Average Mastery
13	52	74.29	Moving Towards Mastery
14	68	97.14	Mastered
15	56	80.00	Moving Towards Mastery
16	50	71.43	Moving Towards Mastery
17	54	77.14	Moving Towards Mastery
18	51	72.86	Moving Towards Mastery
19	40	57.14	Average Mastery
20	40	57.14	Average Mastery
21	53	75.71	Moving Towards Mastery
22	38	54.29	Average Mastery
23	47	67.14	Moving Towards Mastery
24	40	57.14	Average Mastery
25	66	94.29	Nearly Mastered
	SUM	**738.00**	
	MEAN	**10.54**	
	STD	**9.54**	
	MPS	**70.28571429**	

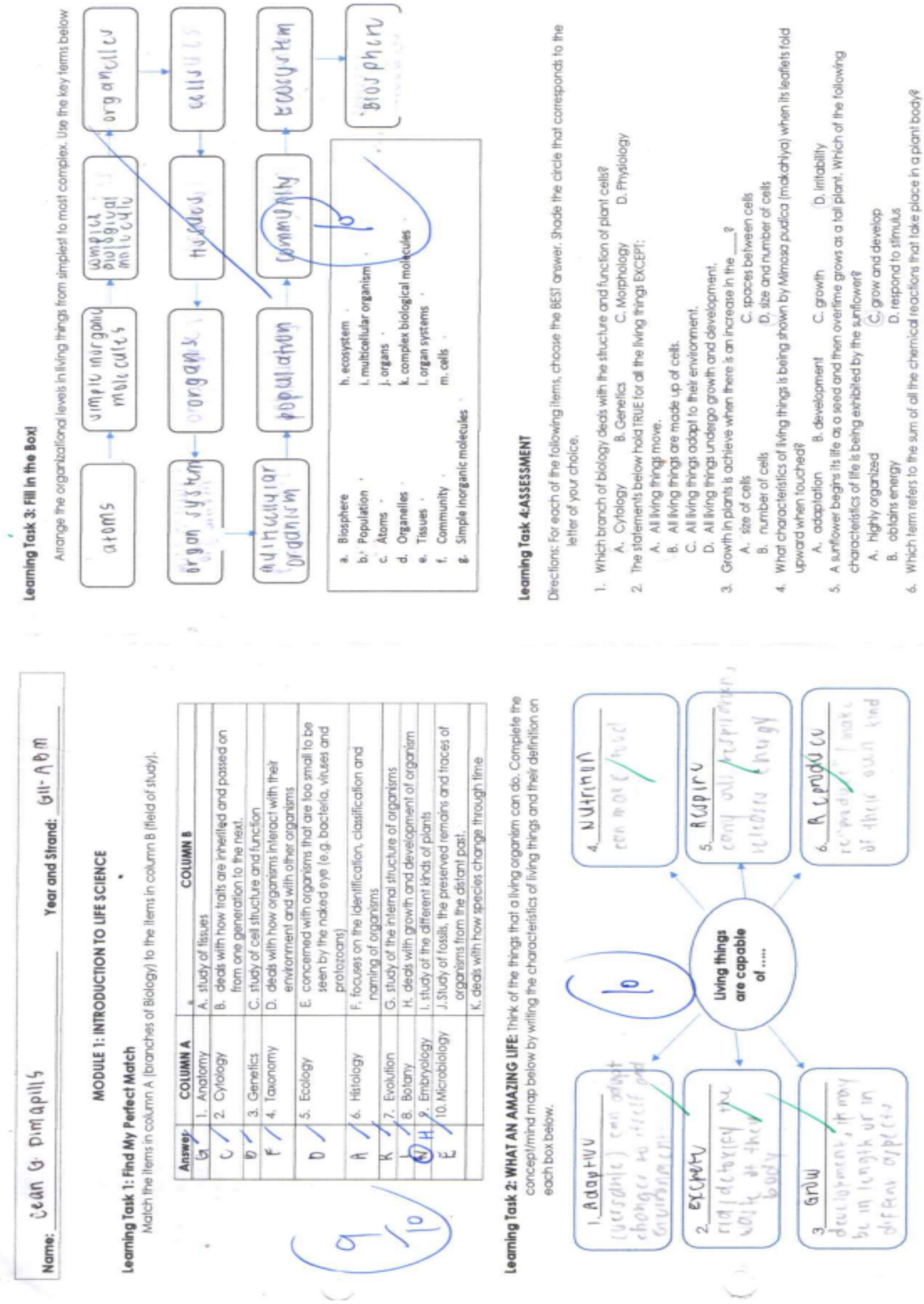

Students' Level of Mastery on Plant Form and Function
9
8
7
6
5
4
3
2
1
0
Mastered
96-100
Nearly Mastered
86-95
Moving Towards Mastery
66-85
Average Mastery
35-65
Low Mastery
16-34
Very Low Mastery
5-15
Absolutely No Mastery
0-4
No. of Test Items

Appendix U: Item Analysis of Energy Flow in the Ecosystem and Biotic Interactions

Test Item	No. Of Correct Answers	% of Correct Response	Remarks
1	66	94.29	Nearly Mastered
2	55	78.57	Moving Towards Mastery
3	53	75.71	Moving Towards Mastery
4	57	81.43	Moving Towards Mastery
5	55	78.57	Moving Towards Mastery
6	61	87.14	Nearly Mastered
7	61	87.14	Nearly Mastered
8	61	87.14	Nearly Mastered
9	62	88.57	Nearly Mastered
10	64	91.43	Nearly Mastered
11	33	47.14	Average Mastery
12	47	67.14	Moving Towards Mastery
13	52	74.29	Moving Towards Mastery
14	58	82.86	Moving Towards Mastery
15	50	71.43	Moving Towards Mastery
16	61	87.14	Nearly Mastered
17	56	80.00	Moving Towards Mastery
18	57	81.43	Moving Towards Mastery
19	63	90.00	Nearly Mastered
20	33	47.14	Average Mastery
21	55	78.57	Moving Towards Mastery
22	33	47.14	Average Mastery
23	46	65.71	Moving Towards Mastery
24	45	64.29	Average Mastery
25	48	68.57	Moving Towards Mastery
	SUM	1332.00	
	MEAN	19.03	
	STD	9.55	
	MPS	76.11428571	


Students' Level of Mastery for Interaction and Interdependence
14
12
10
8
6
4
2
0
Mastered
96-100
Nearly Mastered
86-95
Moving Towards Mastery
66-85
Average Mastery
35-65
Low Mastery
16-34
Very Low Mastery
5-15
Absolutely No Mastery
0-4
No. of Test Items

Appendix V: Sample Accomplished Learning Activity Sheets



Name: cean G. Dimapilis Year and Strand: G11- ABM

MODULE 1: INTRODUCTION TO LIFE SCIENCE

Learning Task 1: Find My Perfect Match

Match the items in column A (branches of Biology) to the items in column B (field of study).

Answer	COLUMN A	COLUMN B
G	1. Anatomy	A. study of tissues
C	2. Cytology	B. deals with how traits are inherited and passed on from one generation to the next.
B	3. Genetics	C. study of cell structure and function
F	4. Taxonomy	D. deals with how organisms interact with their environment and with other organisms
D	5. Ecology	E. concerned with organisms that are too small to be seen by the naked eye (e.g. bacteria, viruses and protozoans)
A	6. Histology	F. focuses on the identification, classification and naming of organisms
K	7. Evolution	G. study of the internal structure of organisms
I	8. Botany	H. deals with growth and development of organism
N H	9. Embryology	I. study of the different kinds of plants
E	10. Microbiology	J. Study of fossils, the preserved remains and traces of organisms from the distant past.
		K. deals with how species change through time

9/10

Learning Task 2: WHAT AN AMAZING LIFE: Think of the things that a living organism can do. Complete the concept/mind map below by writing the characteristics of living things and their definition on each box below.

Living things are capable of .....

1. Adaptive
(versatile) can adapt changes to itself and environment

2. Excrete
rid/detoxify the waste of their body

3. Grow
development, it may be in length or in different aspects

4. Nutrition
can make/food

5. Respire
convert respiration, release energy

6. Reproduce
reproduce / make of their own kind

10

Learning Task 3: Fill in the Box!

Arrange the organizational levels in living things from simplest to most complex. Use the key terms below

atoms → simple inorganic molecules → complex biological molecules → organelles → cells → tissues → organs → organ system → multicellular organism → population → community → ecosystem → biosphere

a. Biosphere	h. ecosystem
b. Population	i. multicellular organism
c. Atoms	j. organs
d. Organelles	k. complex biological molecules
e. Tissues	l. organ systems
f. Community	m. cells
g. Simple inorganic molecules	

6

Learning Task 4: ASSESSMENT

Directions: For each of the following items, choose the BEST answer. Shade the circle that corresponds to the letter of your choice.

1. Which branch of biology deals with the structure and function of plant cells?
   A. Cytology B. Genetics C. Morphology D. Physiology
2. The statements below hold TRUE for all the living things EXCEPT:
   A. All living things move.
   B. All living things are made up of cells.
   C. All living things adapt to their environment.
   D. All living things undergo growth and development.
3. Growth in plants is achieve when there is an increase in the ___?
   A. size of cells C. spaces between cells
   B. number of cells D. size and number of cells
4. What characteristics of living things is being shown by Mimosa pudica (makahiya) when its leaflets fold upward when touched?
   A. adaptation B. development C. growth D. irritability
5. A sunflower begins its life as a seed and then overtime grows as a tall plant. Which of the following characteristics of life is being exhibited by the sunflower?
   A. highly organized C. grow and develop
   B. obtains energy D. respond to stimulus
6. Which term refers to the sum of all the chemical reactions that take place in a plant body?
   A. adaptation C. homeostasis
   B. evolution D. metabolism

Earth Life Science

Name: Cean G. Dimapilis Year and Strand: G11-ABM

WEEK 2: BIOENERGETICS

Learning Task 1: CAN YOU FIND THE HIDDEN WORDS?

There are 10 different words/terms related to the topic of photosynthesis that are hidden in the puzzle. Encircle the word and define or explain how is it related to

P	H	O	T	O	S	Y	N	T	H	E	S	I	S
H	A	X	X	Q	U	L	E	S	O	P	R	T	T
I	S	Y	C	R	N	O	G	A	W	E	U	I	R
O	F	G	V	E	L	P	A	L	M	N	V	C	O
L	E	E	G	W	I	N	L	P	U	Z	V	B	M
K	R	N	F	A	G	B	K	O	H	C	J	L	A
S	T	V	D	S	H	B	I	R	E	T	O	B	U
E	Y	M	R	E	T	A	W	O	V	B	N	S	I
R	U	H	E	J	D	S	U	L	A	S	D	F	E
S	D	I	O	K	A	L	Y	H	T	E	R	T	O
W	O	P	R	H	V	N	R	C	D	F	G	H	P
L	I	G	H	T	R	E	A	C	T	I	O	N	M
C	A	R	B	O	N	D	I	O	X	I	D	E	B

10/10

1. PHOTOSYNTHESIS- a process used by plants & other organisms to convert light energy into chemical energy that can later be released to fuel the organisms activities
2. OXYGEN- an oxidizing agent that readily forms oxides with most elements as well as with other compounds
3. GLUCOSE- a sweet colorless soluble dextrorotatory form that occurs widely in nature & usually form in which carbohydrate is assimilated by animals.
4. STROMA- refers to the colorless fluid surrounding the grana within the chloroplast
5. THYLAKOIDS- are membrane-bound compartments inside chloroplasts and cyanobacteria
6. LIGHT REACTION- is the process of photosynthesis that converts energy from the sun into chemical energy in form of NADPH and ATP.
7. WATER- an inorganic, transparent, odorless, & nearly colorless chemical substance — provides electrons by splitting into hydrogen & oxygen atoms hydrolysis
8. SUNLIGHT- a portion of the electromagnetic radiation given off by the sun.
9. CHLOROPLAST- organelles found in plant cells and eukaryotic algae that conduct photosynthesis
10. CARBON DIOXIDE- a heavy colorless gas that is formed by burning fuels, by the breakdown & burning of animal and plant matter, and by the act of breathing & that is absorbed from the air by plants in photosynthesis.

10/10

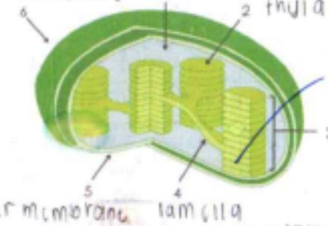
Write the complete and balanced chemical equation of photosynthesis

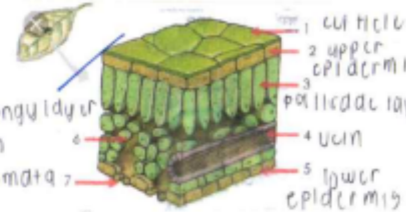
$6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$

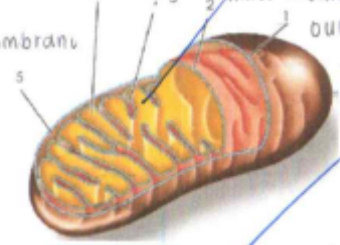
5/5

Learning Task 2: LABEL ME!

Below are the pictures of chloroplast and leaf anatomy. Label the numbered parts. You may use separate sheet for the description of each part.







10/10

Learning Task 3: LET'S COMPARE!

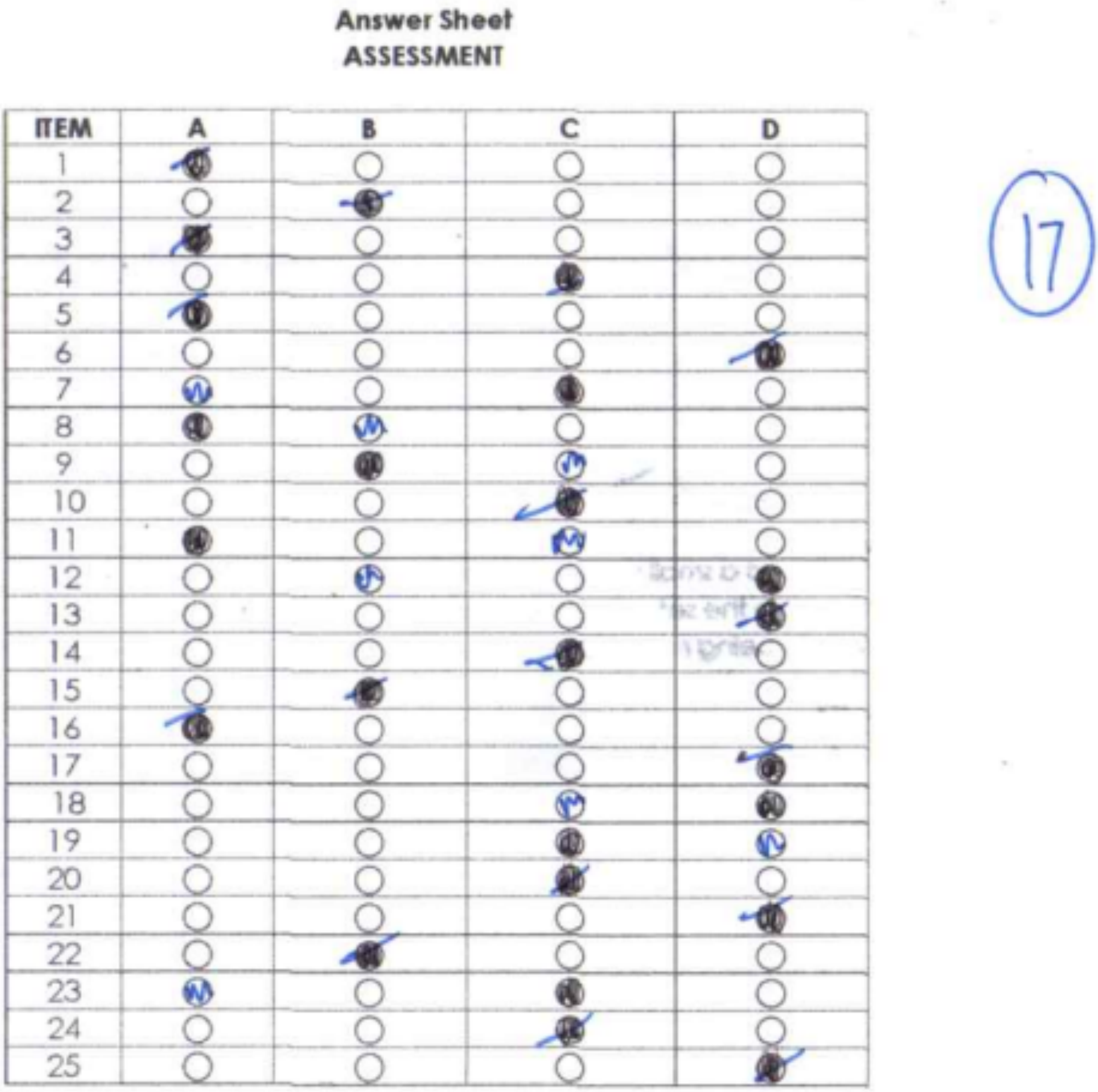
Complete the following table by comparing and contrasting the light-dependent and light- independent reactions of photosynthesis.

A. Comparison between the two photosynthetic reactions

Point of Comparison	Light-dependent Reactions	Light-independent Reactions
1. Raw Materials	CO_2, H_2O, sun's energy	uses the stored energy from light-dependent reactions (L-DR)
2. Parts of the chloroplasts where they occur	thylakoid membrane	stroma
3. Light requirements	use light energy to make 2 molecules: NADPH & ATP	requires the products of (L-DR) to function
4. Chemical reactions involved in the process	ATP & NADPH	fixation, reduction, & regeneration
5. End products	ATP, NADPH, and O_2	glyceraldehyde 3-phosphate
6. By-products	ATP, NADPH, O_2	reduce CO_2

9.0/10

Appendix W. Sample Corrected Answer Sheet for Weekly Assessment



Answer Sheet
ASSESSMENT

ITEM	A	B	C	D
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24				
25				

17

Appendix X: Accomplished GBL Activity Sheets

Activity 1: Crazy Little Thing Called Life

ATA AND RESULTS

tions: List down 10 things that you can find in your home garden. Using the MRS GREN criteria ation, check the column of the characteristic/s exhibited by the object you have identified. ide whether the object is living or non-living.

gs in our Home Garden	M	R	S	G	R	E	N	Living?	Non-Living?
KS			✓	✓					✓
S									✓
RM	✓	✓	✓	✓	✓	✓	✓	✓	
ER	✓	✓	✓	✓	✓	✓		✓	
S	✓	✓	✓	✓	✓	✓		✓	
Y	✓	✓	✓	✓	✓	✓		✓	
E	✓		✓	✓				✓	
L							✓		✓
TER							✓		✓
N	✓							✓	

: **M**- movement; **R**- respiration; **S**- sensitivity; **G**-growth; **R**- reproduction; **E**- excretion; **N**- nutrition

10/10

ESTIONS

are the living things you have identified from this activity? How about the non-living things?

living Things are worm, Spider, Ants, Fly, Rose and while the non-living Things are Rocks, Pots, Soil Water. 5/5

characteristics are found only in living things? found both in living and nonliving?

e characteristics that are found only in living things movement, respiration, reproduction excretion and nutrition the characteristic that are found in both living and living thing is sensitivity and Growth 5/5

o the living things you have identified obtain their nutrition? respond to their environment?

or the insects they obtain their nutrition by eating er living things while the plants get their food absorbing sunlight, carbon dioxide, water and also ients from the soil. 5/5

Page | 1

APPLICATION

1.How can farmers/gardeners use their background/knowledge on the characteristics of living things in taking care of their plants?

Through those characteristics, it can help gardeners to be aware on how to handle or take care of their plants. In order to properly care for the soil and the crops that grow in it, they will ensure proper nutrition for the plants.

5/5

2. How does irritability contribute to chances of survival?

Irritability is the ability of the living organisms to respond to changes in their environment. through irritability they can protect themselves from harmful things and they never let other unnecessary organisms ruin their chance of survival.

5/5

3. Would you consider novel corona viruses living or non-living? Justify your answer.

I think i'll consider it Living organism because it has cell Just like other Living organism and its also moving in air but without us seeing it only using some devices like microscope. I think its another kind of living organism

5/5

4. Most plants are stationary (fixed in one location). Does it affect their ability to reproduce and obtain their food?

No. Most plants are stationary because they can

CONCLUSION

for this lesson I clearly understand the characteristic of living things which are Movement, Respiration, Sensitivity, Growth, Reproduction, Excretion and Nutrition these characteristics serves to define life

5/5

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"The love for all living creatures is the most notable attribute of man"
- *Charles Darwin*

Activity 11: Make Your Own Herbarium

DATA AND RESULTS

FLORA OF TANAUAN CITY

Bry. Pantay Matanda, Tanauan City, Batangas

Family: Oxalidaceae **Field No.:** ______

Scientific Name: Averrhoa bilimbi

Local Name and Dialect: Belimbing

Collector's Name: Lovely Ann B. Terino

Locality: Pantay Matanda, Tanauan City, Batangas

Habitat: dry season

Habit Description: Bilimbi leaves are alternate, pinnate, measuring approximately 30-60 cm in length

Economic Use: used for boils, with cough, hypertension, mumps and pimples.

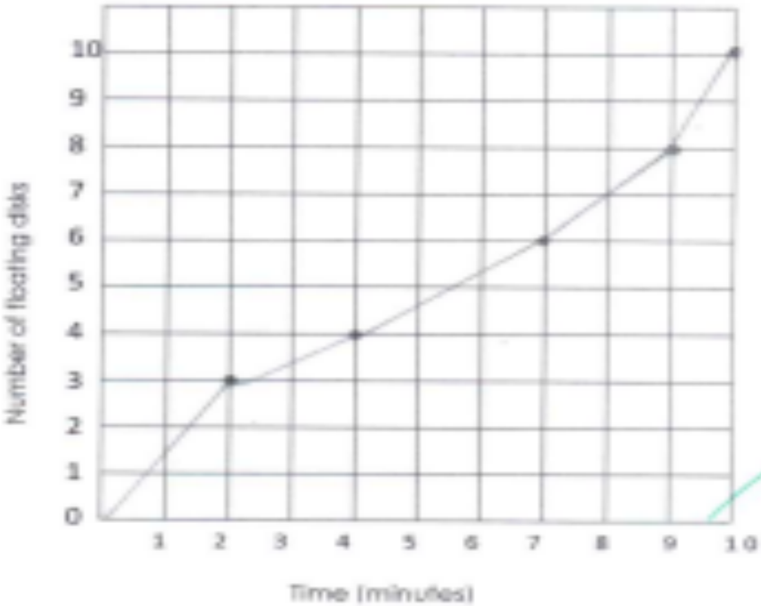
10/10

Page | 30

Activity 4: Evidence of Photosynthesis

DATA AND RESULTS

Directions: Record how many disks remain floating after each minute until all of them have sunk on the graph below.



Guide Questions:

1. What is the purpose of the baking soda solution in the treatment set-up?
   The sodium bicarbonate provides dissolved CO_2. Leaf/Plant will generally float in water. This is because leav[illegible] air in the spaces between cells, which helps them collect CO_2 from their environment to use in photosynthesis.

2. Describe what will happen when both the control and treatment set-up was expose[d to] light source.
   Light is essential for photosynthesis. Green plant cells are placed in the dark will not photosynthesis. The light is changed by decreasing the light intensity. The rate of photos[illegible] should decrease and therefore the amount of oxygen bubbles [illegible]

3. Why do the leaf disks in the baking soda solution (treatment) begin to float?
   The leaf disks intake carbon dioxide from a baking so[illegible] solution and sink to the bottom of a cup of water. When ex[illegible] to light, the disks use carbon dioxide and water to produce oxy[illegible] glucose. Oxygen released from the leaves forms tiny bubbles that cause [illegible]

Activity 6: Propagating Plants through Stem Cuttings

DATA AND RESULTS

Directions: Take a photo of your planted stem cuttings. From day 0, day 5, day 10 and day 20.

Day 0 | Day 5 | Day 10 | Day 20

GUIDE QUESTIONS

1. What form of asexual reproduction did you perform in this activity? Name other forms of asexual reproduction undergone by plants?

5/5

Vegetative reproduction because a new plant grows from a fragment of the parent plant or a specialized reproductive structure. the other forms of asexual reproduction are self pollination and [illegible]

2. How will you describe the genetic composition of the stem cuttings of portula and the mother plant from which it was derived?

5/5

A piece of the stem or root of the source plant is placed in a suitable medium such as moist soil. A stem cutting produces new roots, and a root [illegible] produces new shoots.

3. What are some benefits to asexual propagation? What are some potential problems with asexual propagation?

5/5

the ~~problems~~ plants grown asexually lose the natural genetic diversity that occurs when growing from seeds and for the benefits it is faster and more certain method of propagation and this preserves the characteristic of food and flower [illegible]

4. Can you give other plant species, that can be propagated through stem cuttings?

5/5

Sugar cane, roses, citrus, durant, grapes, cacao, bougainvillea, carnations and many other plants are largely and rapidly propagated by stem cutting

Page | 16